THE FINISHING
OF
TEXTILE FABRICS

(WOOLLEN, WORSTED, UNION AND OTHER
CLOTHS)

BY

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WITH 151 *ILLUSTRATIONS OF FIBRES, YARNS, AND FABRICS,*
ALSO SECTIONAL AND OTHER DRAWINGS OF
FINISHING MACHINERY

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CHAPTER I.

WOOLLEN, WORSTED AND UNION FABRICS.

(1) Woollen Cloths: Saxonies and Cheviots. (2) Worsted Fabrics: Botany and Crossbred. (3) Fancy and Piece-dye Woollens. (4) Fancy and Piece-dye Worsteds. (5) Union Fabrics: Piece dyes and Fancies. (6) Whipcords, Buckskins, Venetians, Cords and Twist-warp Fancies. (7) Heavy Woollens: Box Cloths, Meltons, Pilots. (8) Friezes, Shetlands and Naps. (9) Special Types of Overcoatings. (10) Golf Cloakings. (11) Vestings.

(1) *Woollen Cloths: Saxonies and Cheviots.*

Woven manufactures in which wool and wool substitutes are used, are divided into the woollen, the worsted and the union-fabric industries. In the woollen industry, the chief divisions are "Saxony" and "Cheviot". The terms have originated in the difference in the grades of wool used in each branch of the trade. Formerly, fine woollen cloths, such as those of which the staple trade of the west of England consisted, were made, largely, of Saxony and Silesian wools. The development of the Colonial merino-wool industry has resulted in the fine cloths made in this country being composed mainly of Colonial wools; but the term "Saxony" has been retained as defining the nature of the fabrics. The "Cheviot" designation has arisen from Cheviot wools being used in the production of these fabrics in the early history of the tweed trade. But here again the varieties of wool have much increased in recent years, both in Great Britain and Ireland, and also in the wool-growing countries of Australia, New Zealand, the Cape, Natal and South America.

Saxony and Cheviot cloths differ in (*a*) fineness; (*b*) quality of handle; (c) textural surface; and (d) wearing property. Saxonies are characterised by fineness and density of fabric, soft quality of handle and smooth surface: Cheviots are rougher in appearance, more porous in nature or open in structure, and have a comparatively strong-fibred surface, as in the Irish frieze. Industrial requirements, are, however, tending to destroy this distinctiveness of cloth—the qualities of Saxonies and Cheviots approaching each other in an increasing degree. This is more apparent in Cheviots, where the use of finer wools in the better-class fabrics has imparted some of the distinguishing qualities and features of the Saxony.

(2) *Worsted Fabrics: Botany and Crossbred.*

Worsted, like woollen manufacturing, consists of two main divisions, namely, "Botany" and "Crossbred". The former term is applied to the finer grade of textures, and was given, originally, to indicate merino wools shipped from Botany Bay, New South Wales, but now also denotes all similar qualities of wool wherever grown. "Crossbred" defines the more serge-like or rougher types of worsted fabrics. It will be observed that the two terms have synonymous meanings to "Saxony" and "Cheviot" in the woollen industry, for they describe the fine and coarse classes of fabrics respectively.

There are many intermediate grades of worsteds between the pure Botany and the pure Crossbred. The peculiar characteristics of the Botany are fineness of texture, clearness of surface and "quality"; and those of the Crossbred, comparative roughness, and crispness of handle. Similar qualities of wool may be used in Saxony (woollen) and Botany (worsted): and also in Cheviot (woollen) and Crossbred (worsted): so that clearly any difference in these woven manufactures is not, necessarily, in the raw material or fibre, but in the routine of yarn manufacture. The two distinct systems of yarn-making, woollen and worsted, are the cause of fabrics so different from each other in appearance and quality; and of the varied treatment to which they are subjected in the finishing processes subsequent to weaving.

(3) *Fancy and Piece-dye Woollens.*

Each class of the woollen, the worsted and the union-fabric industries is subdivided into "fancies" and "piece-dyes". The term "fancies" is applied to cloths in which the pattern is developed in weaving, and not in dyeing, printing or any other process; the latter to fabrics dyed in the piece, or made of yarns in the natural colour of the wool, as distinct from wool or yarn-dyed cloths. The terms are occasionally somewhat misleading, because piece-dyes may be striped, checked or spotted with colour, when the effects or patterns correspond to those produced in the loom. Such effects are due to the dyeing properties of animal and vegetable fibres, which in the same dyeing operation take different tones of colour.

Woollen "fancies" comprise a wide range of textures, including flannels, flannel suitings, costume cloths, trouserings, suitings, overcoatings, golf cloaking, mantles, rugs and shawls. Each of these may require special treatment in the processes of finishing. Flannels and costume cloths are classed together as regards weight and style of texture. In Saxonies, trouserings may be a distinct type of fabric from suitings or coatings, but this, as a rule, is not the case in Cheviots made for the same purpose. Much variety of colouring and design, thickness and construction of fabric, and style of finish, obtain in the heavier fabrics for rugs, mantles, etc. Between the two extreme weights, namely, the lightest texture from about 7 to 10 oz. to the yard, and the heavier cloths, 32 oz. to the yard (these are not the limits, as special cloths are made over 48 oz. per yard), there are many grades of fabrics both in materials and qualities. Where such differences exist in woven productions, or in the amount of fibre in the cloth, as indicated by these weights, there is corresponding scope for diversity of finishing.

More complete standardisation is possible in "piece-dye" than in "fancy" fabrics. Included in the more important types of piece-dye woollens—which are generally well felted and raised—are the following: "soft-finish" costume cloths, "plain supers," "doeskins," "beavers," "billiards," "Sataras," "box," and other cloths. It should be observed that wool-dyeing is also practised in making such fabrics. One of the leading characteristics of each of these cloths is the fibrous or dress-face surface. This quality is a distinct effect of the processes of finishing, for it does not exist in the cloths in the loom. In the first place, by the process of milling, density of texture is acquired, that is, individual threads of warp and weft are felted into one composite mass of fibres; and secondly, by the process of raising, fibres are straightened and combed in one direction over the face of the fabric, concealing traces of separate warp and weft yarns. The methods of manufacture followed, produce a woven surface suitable to such treatment in finishing.

Considering the types of fabrics in the order named above the "costume" cloth and the "plain super" are the simplest in construction, varying in shrinkage from 15 to 25 per cent., but the "super" is more highly finished, possessing a denser pile and a more lustrous surface. "Doeskins," "beavers," and "billiards" are stronger and firmer made, but otherwise have similar qualities, with the surface fibre short, dense and bright. The "Satara" is one of the oldest of woollen cloths, ribbed or striped in the weave, weft ways. There is no branch of the woollen industry in which a greater degree of skill and experience is exercised than in the production of the finer qualities of these fabrics. Finishing effects changes in the condition and appearance of the cloth, but at the same time is liable to accentuate any fault formed in the preceding processes of yarn and fabric structure. This applies to all classes of fabrics dyed one colour, and which are well milled and lustred by boiling or crabbing, and pressing.

(4) *Fancy and Piece-dye Worsteds.*

Fancy and piece-dye worsteds are more diversified in structure and weave than woollens. As observed, variety of yarn construction and systems of finishing are the two principal sources of the several classes of woollen fabrics, but in worsteds of all kinds, there is a large diversity of woven fabrics resulting from weave, and build or make of texture. If the scope for distinct fabrics were restricted to weave elements alone, unlimited possibilities would be afforded for variety of texture. Weave includes such typical effects as fancy twills, mats, ribs, cords, sateens, corkscrews, diagonals and honeycombs. Many of these are capable of re-arrangement and of combination with each other, forming groups (which are also subdivided into other classes) of textile patterns. Such patterns may be either fancy or piece-dye, the colours being applied in weaving, or the fabrics may be woven in the grey and dyed afterwards.

Fancy worsteds are grouped into three classes:—

(*a*) Dress and costume textures.

(*b*) Suitings, trouserings and coatings.

(*c*) Heavy cloths, such as overcoatings, mantle and decorative textures.

Class (*a*), in addition to the ordinary types of woven fabrics, comprises lenos, gauzes, lappets, and many other styles which bear special trade names, such as zibelline, crêpeline, voile, crêpe de chîne, and canvas cloths. They are commonly single in structure, but double weaves may be used in figured fabrics. Classes (*b*) and (*c*) comprise single, backed and compound structures, and are subdivided into (1) colour fancies, in which the patterns are simple in weave and due to colour, consisting of stripes and checks; (2) weave fancies, invariably piece-dyes; and (3) fancy patterns, composed of two or more weaves and colours, and of various forms of design. Type (1) is also common to woollens, but types (2) and (3) are distinctly characteristic of worsteds, though in elementary styles they may be made in woollen yarns.

A special feature of worsted manufacturing—which has not the same recognition in woollen manufacturing—is "quality". This enters into every branch of the trade. Two fabrics may be identical in counts of yarn, setting, finish and all other data, but one finer in quality, to a recognised or standard degree, than the other. It is in the latter point that the difference between two similar woollen and two similar worsted fabrics is distinguishable. In the case of the woollen, quality is not fixed or standardised, whereas in worsted manufacturing it is approximately defined. Top making is the basis on which this fineness is fixed. For example, a 60's top may be spun to a 60's yarn (usually the extreme limit) or it may be spun to a 40's, in which instance it should yield a better thread than if spun to the higher counts. This applies to the several kinds of worsted, mohair and other yarns, in which the material is prepared in the top form. If a worsted fabric is made from yarn lower in counts than the quoted top, it should be correspondingly finer than a similar fabric made of the same counts of yarn, but in which the highest possible counts has been spun from the quality of top used. This difference in quality is more perceptible in piece-dyes than in fancies, where the design and colour may conceal the inferior character of the material, but in the handle and wear of the fabric the absence of quality would be apparent.

Fabric structure is very diversified in worsted manufacturing. In piece-dyes there are such standard makes of texture as the weft-backed cloths, warp-backed cloths; double cloths, with the same counts of yarn on the face and back; and double cloths, with thicker counts of yarn on the back than on the face; and other compound weaves. The warp yarns are, as a rule, twofold, but the weft may be either twofold or single. When softness of handle is required, single woollen weft may be used, and still the cloth styled a worsted.

One quality that should, generally, be paramount in worsted fabrics is smartness and brightness of weave and colour.

(5) *Union Fabrics: Piece-dyes and Fancies.*

Several classes of union cloths are of modern construction and manufacture. Until a few years ago the term "union" was mainly descriptive of fabrics composed of cotton warp and thick mungo or shoddy weft, or cloths which still largely constitute the low branch of the woollen industry. Now the word has a broader meaning, union fabrics being variously constructed. For example, the *warp* may be worsted, and the *wefts* fine cotton and woollen, in making a cloth in imitation of a solid worsted; or in the better quality of union, the *warp* worsted, and the *weft* woollen. One of the principal objects to be attained in the manufacture of unions, is the production of a type of fabric of similar qualities to cloths made in the higher branches of the trade, as cheaply and economically as possible. There is a like diversity in weight and style of cloth as in the woollen trade. The finish is equally diversified.

Piece-dye unions are distinctly imitations, in appearance and other qualities, of woollens of the milled and raised type. Meltons, presidents and pilots are the more important varieties. The routine of finish has, therefore, to be similar to that of all-wool fabrics. But in structure, scheme of weaving and other technicalities, unions are distinct from woollen cloths, of which they are imitations at a reduced cost. Union costume fabrics are similar in colour and finish to light-weight dress-face woollens. Presidents and pilots resemble, in surface characteristics, the woollen beaver cloth. The degree of lustre developed in these fabrics, considering the materials used, shows the skilful manufacture practised in their production. Invariably the warp is cotton and the weft thick mungo or shoddy, and hence the woven structure has to be such as to conceal the cotton yarn and make it feasible, by felting and raising, to cover the face of the cloth with fibre, which can only be obtained from the weft yarn. If a beaver and a president are compared, the superiority is obvious in the fulness and fineness of fibre in the pile of the woollen production. This is not remarkable when it is considered that both the warp and weft yarns have contributed to this fibrous condition, and the larger proportion of threads to the inch than in the union.

Worsted piece-dye unions are fabrics in which the worsted warp alone shows on the face, with a binding cotton weft thread and mungo yarn for the back. To improve the handle and appearance of the cloth, the under side is raised, the face being treated as in the finishing of a worsted.

"Union fancies" are chiefly utilised in the ready-made clothing industry. Whatever quality of texture, nature of colouring or design are originated in fancy worsteds and woollens, are reproduced in these lower grades of woven manufactures. The designations applied to the genuine woollen or worsted are also used for the low-class fabric.

The chief methods of union cloth manufacture comprise:—

	WARP.	WEFT
1. Union prints . . .	Cotton.	Mungo.
2. Low-class fancies . .	Soft spun cotton twist.	Mungo or shoddy.
3. Low Cheviots . . .	Shoddy.	Shoddy.
4. Low woollens . . .	Mungo.	Mungo.
5. Union worsteds: Costumes	Part cotton twist and part worsted.	Same as warp.
6. Union worsteds: Coatings	Worsted.	Cotton and mungo.
7. Union blankets and rugs .	Cotton.	Shoddy or lustre worsted noils.
8. Dress fabrics . . .	Cotton.	Lustre worsted or mohair.
9. Flannels	Single cotton.	Single cotton.

The first type closely resembles a woven pattern, but the texture of the cloth is naturally harsh and wanting in tone. Classes 2 and 3 also approach the woollen fabric in effect, the best qualities of the fibre being developed in finishing. Some union fabrics, *e.g.* Group 5, are as satisfactory in the finished cloth as a worsted for wearing in a warm season, on account of the cool quality of the cotton. Rugs, dress fabrics and flannels also form important branches of the union trade.

Unions of all grades have a useful place in the woollen industry, constituting the chief source of utilisation of otherwise textile waste products.

(6) *Whipcords, Buckskins, Venetians, Cords and Twist-warp Fancies.*

These are woollen fabrics in which the weave effect may be almost as clear and decided in tone as in a worsted fabric. The reason for this is that the warp yarns are folded, or two threads twisted together, varying in degree of twine according to the character of the cloth required. This process of doubling or twisting yields a level thread, one adapted for giving a more precise effect to the weave structure than the ordinary single woollen yarn. In order to prevent undue hardness in the texture which twist yarns sometimes produce, the weft is usually soft spun, and may be slightly thicker in counts than the warp.

One of the simplest and oldest kinds of these fabrics is the "whipcord," of which the weave is an ordinary $\frac{3}{\ }\frac{\ }{1}$ warp twill. The cloths are well felted to give the sound wearing quality which is requisite. The "buckskin" is another standard woollen, of a finer twilled effect, than the "whipcord". It is the reverse in character to a "doeskin". Both cloths are excessively milled, yet one is a soft fibrous texture and the other a pronounced, but fine twill, due to the twist warp. The "Venetian" is similar in construction to the "buckskin," but finer in the weave. It is the standard covert coating cloth, and may be produced in three qualities: (1) With the fine twilled weave clear and distinct, when the warp yarn is twofold, either worsted or woollen, and the weft single woollen; (2) single yarns in warp and weft, and the fabric slightly raised in finishing, subduing the twill effect; and (3) the piece-dye Venetian, with the twill either clearly developed or softened by raising the fibre, and in which the warp yarn may be either single or twofold.

Woollen ribs or cords, *e.g.*, Bedford cords, are frequently twist, or folded yarns in the warp. The pattern consists of ribs or reps, the fulness of each stripe due to the weave structure being increased by inserting thick wadding threads between the face warp and the weft. The weft is arranged to stitch the warp in twill or plain order and float on the back of the cords alternately: that is, if the odd picks form the face effect in one cord, they appear on the under side of the adjacent cord and the even picks *vice versa*. Finishing should develop this structural feature of the fabric by milling moderately to produce cover on the back, and by cutting close to remove, from the face, extraneous fibre.

Whipcords, buckskins, Venetians and Bedford cords, even when striped and checked with fancy colours, are woven in standard weaves, to which the same designations are applied.

Twist-warp fancies obtain in light, medium and heavy fabrics. In the extreme fancy manufactures for costume and similar cloths a rich variety of twists is used. Such folded yarns may be composed of woollen, worsted, mohair, cotton and other fibres. In no type of texture and pattern are more pronounced changes developed in finishing than in those consisting of knop or flake twists. Prior to milling and raising, the projecting parts of the folded yarns may be of solid knops of fibres. By raising, each compact mesh of fibres forming such spots or knops are spread or combed over the face of the fabric.

(7) *Heavy Woollens: Box Cloths, Beavers, Pilots, Meltons.*

These are typical of the substantial heavy woollen cloths made of wool and wool substitutes, ranging from 28 to 36 oz. to the yard. Such cloths are necessarily hard felted, being set from 80 to 90 inches in the reed, if made of wool of good fulling property. It is only possible to obtain cloths of this weight by two other methods than milling. First, the use of thick yarns; second, of compound weaves. Neither method would produce the sound, firm and compact texture which characterises box cloths and meltons. If the weight resulted from thick yarns, the texture would suffer in fineness, and if from using a compound weave, in firmness of construction. Excessive milling is, therefore, an essential in the finishing of this heavy kind of cloth.

"Box cloths" are made in several shades of drab. Wool dyeing is usual to secure a perfectly even colour in the finished cloth. Fabrics so well milled are not so porous as an ordinary woven or milled texture, and as a consequence the dye would penetrate less freely, hence the advantage of wool dyeing. Carriage cloths, with either a lustrous or semi-lustrous face, should be classed with box cloths, being of a similar structure and felted character. One of the common weaves for both box and carriage cloths is the $^{2}_{2}$ twill cutting 2's, the alternate picks interlacing plain giving the necessary sound build of texture.

The "pilot" cloth is not so hard and firm when finished as the box cloth. Neither has it the fineness and quality of the "beaver," which should be as lustrous and as soft in the handle as the single-make doeskin, with additional firmness and weight.

While the pilot is a single-weave fabric, the beaver is frequently backed or double. If single, the weave is a sateen or a make that brings more warp than weft on to the face, and the warp should be a better quality than the weft and have a higher raising property. There is, therefore, a difference in the methods of weaving. In the pilot, the warp and weft consist of medium counts of yarn and are equally on the face of the fabric, but in the beaver a finer and better quality of yarn may be on the face than on the back. As a result, it is feasible to obtain a smart, fibrous finish which forms the principal characteristic of the beaver cloth.

"Meltons" are another special type of milled cloth. The yarn and method of weaving may be identical with a box cloth, yet the surface of the finished fabric is different. There is no laying of the fibre in the process of raising. It is allowed to project vertically, offering the same slight resistance in whichever direction the hand traverses the face of the cloth. This is an essential quality, combined with firmness and strength of construction. Such a fibrous surface has better wearing properties than that of the doeskin or beaver, the entire mass of the ends or tips of the fibres sustaining a degree of the friction in the wear; whereas the lateral surfaces of the fibres mainly resist the friction in the beaver-finished cloth.

Another element which should be noted in contrasting lustrous pile-finished cloths with those of the melton class is, that the latter—providing all details of construction are the same—is likely to possess a greater tensile strength. The lustre applied in producing the fine pile of the doeskin does not tend to add to the elasticity and strength, but rather the reverse. The repeated processes of boiling and raising, necessary to develop and fix the brightness of pile, reduce to a greater degree the strength of the cloth than the mere raising, to produce a dense, vertical, non-lustrous pile, as in a melton.

(8) *Friezes, Shetlands and Naps.*

"Friezes" and "Shetlands" are rough-surfaced tweeds made of coarse-fibred wool, and also of wool substitutes and mixtures of wool, shoddy and mungo. The "frieze" was originally an Irish production. It is used for heavy overcoatings. The apparent roughness of texture may be increased by raising and "napping". Friezes are made in mixtures, such as greys, browns, olives and blues. Thick yarns are used—some 8 to 10 yards to the dram—and the pieces are set loose in the loom to provide a degree of shrinkage that will partially cover the weave and develop and fix the fibrous nature of the surface of the cloth.

The "Shetland" also possesses a fibrous quality. Similar materials, counts of yarn and setting are common to both fabrics. The chief difference is in surface characteristics, the Shetland being somewhat softer in handle and more closely approaching an ordinary heavy tweed.

"Naps" form another standard type of thick overcoatings. The face of the fabric is covered with "naps" or small curls of fibres. Though possessing fulness of handle, these cloths are comparatively light. This is a feature in which they differ from both friezes and Shetlands. The nap is a development of the process of raising and "napping" or rubbing of the pile of fibres into minute beads or curls. This effect may be partially obtained by other methods. For example, when in Crossbred serges loose weave structures are employed, rapid felting occurs, and the yarns buckle or loop, causing the fabric to have a "napped" appearance on the face.

The varying shrinkage properties of fine and coarse wools, and of wool and mohair, also make it feasible to produce this curly condition of fibres in woven fabrics. Should a lustre yarn float loosely on the face of the texture, and a Saxony interweave with the warp to make a fast foundation fabric, then in milling, the Saxony, having greater felting property, causes the mohair or lustre worsted to buckle or loop. Imitation astrakhans and other curl fabrics are woven in this way. Such effects cannot be strictly defined, even when sufficiently minute, as naps, for the fibres are looped on the yarn and not raised out of the warp and weft by friction in the operation known as "napping".

(9) *Special Types of Overcoatings.*

In addition to the standard types of thick fabrics to which reference has been made, there are special makes of heavy cloths constructed for mantles, cloakings and overcoatings. Compound fabrics with woven linings are an important variety. Here the two sides of the cloth may be different in weave, materials and colouring. Indeed, in these details, the distinction may be as marked as between a fabric and the lining used in making the garment.

When the materials for the face and back are dissimilar, *e.g.*, worsted and woollen, Saxony and Cheviot, the finishing routine for each has to be modified. As for instance, in an overcoating with fine worsted yarns composing the face texture, and Saxony yarns the under side, then the former would be a clear, smart finish, and the latter slightly raised or a "fibrous" finish, acquiring in one cloth both the characteristics of the worsted and the Saxony, yet each distinct from the other.

There is also a diversified class of overcoatings in mixtures and solid colours raised on one or both sides, but different in length of pile, or some other feature, from the standard cloths described. These are chiefly special in weave, being double and treble in structure. The manufacture of such cloths also involves something new, or different in yarn construction, or the utilising in the same fabric yarns of several fibres or qualities, such, for example, as Saxony and mohair, Botany and Crossbred worsted. The kind of yarn to be used is determined by the lustre and softness of texture required, and also by the length of pile to be developed on the surface of the cloth.

In reversible heavy cloths, both surfaces may be composed of the same yarn, or with a lustre yarn for the face and a non-lustre for the under side, with a fast spun yarn for the centre, giving a structure that may be heavily raised on both sides.

Generally, the fibrous-faced cloths described range in weight from 30 to 34 oz. per yard, and are set loose in the reed, 72 to 90 inches wide, for the standard width finished, according to the firmness of fabric and character of surface required for finishing.

(10) *Golf Cloakings.*

Golf cloakings come in the same category as heavy fabrics with woven linings. They are made in a large diversity of materials and counts of yarn, and usually with quite a distinct quality of finish on the under side from the face side. In the coarser fabrics, Cheviot yarns, or yarns of a lustrous nature, are used for the face, and Saxony yarns for the lining. In the finer qualities, worsted yarns for the face and fine Saxony for the under side, as in Fig. 1. This cloth illustrates, in a typical way, the difference in finish, as well as in texture, possible in such cloakings. One side of it is composed of fine worsted yarns in a clear, smart twill, and finished on the worsted principle; the lining, on the other hand, is covered with fibre, being made of yarn which yields a woolly surface in the milling machine. The contrast as to texture, handle and surface, is as marked in this cloaking as between a pure Botany worsted and a pure Saxony. Strictly, there are two textures inde-

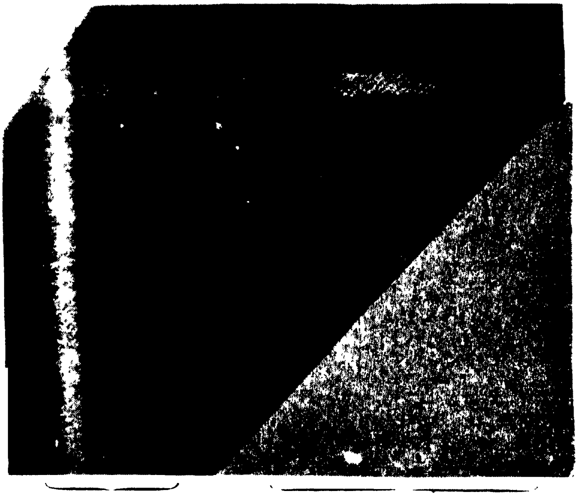


FIG. 1.

pendently constructed, though regularly stitched together in weaving. This principle of fabric structure and finish applies to the many kinds of mantle, wrap and rug cloths.

(11) *Vestings.*

Perhaps no type of woven fabric is produced in so many schemes of manufacturing as fancy vestings. They are knitted as well as woven, in simple and complex designs. An almost unlimited range of yarns is utilised in their construction. It follows that the finishing routine is alike diversified.

Technically, the typical methods of weaving are as follows :—

(*a*) Solid worsted vesting, in weave compounds, weighing approximately 10 oz. per yard, narrow width.

(*b*) Saxony warp and weft vestings, for heavier cloths, 13 to 15 oz. per yard, narrow width.

(*c*) Woollen Cheviot vestings.

(*d*) Union vestings : –

  (1) Cotton warp, worsted weft.
  (2) Cotton warp, woollen weft.
  (3) Fine worsted warp, closely set with cotton binding weft and woollen weft for backing.

These methods of manufacture may be modified according to the kind of fabric to be woven. Silk, or mercerised cotton, form the extra yarn in the finer fabrics, but worsted, in bright shades, is preferable for Saxony and Cheviot vestings. The Saxony cloths are frequently double in structure, and the spottings or other effects on the face are due to reversing the weaves and yarns.

CHAPTER II.

PROCESSES OF FINISHING AND THEIR EFFECTS.

(12) Qualities of Unfinished Woollens. (13) Worsted Fabrics and Finishing. (14) Preliminary Work. (15) Finishing Processes. (16) Scouring and the Detergents Used. (17) Hydro-extracting. (18) Tentering and Drying. (19) Felting and its Effects. (20) Condition of the Piece in Milling. (21) Potash and Soda Soaps. (22) Effects of Raising. (23) Influence of Textural Conditions on Raising. (24) Theory of Raising and the Twine in the Yarn. (25) Fabric structure and Raising Surface. (26) Several Kinds of Raising—Dewing. (27) Lustring Processes. (28) Pressing.

(12) *Qualities of Unfinished Woollens.*

ALL woollen fabrics in the unfinished or "balk" condition, or when removed from the loom, have a loose, thready structure, and may be easily unravelled, or the warp and weft yarns separated. The interlacings of the weave are also clear, and there is an absence of cohesiveness of fibres in the individual threads. In this condition, the strength and elasticity of the fabric are chiefly determined by the frequency with which the warp and weft are interlaced in weaving. The quality and soundness of the yarns primarily affect the tensile strength of the cloth, but, prior to finishing, the fabric, in any quality of yarn, owes its firmness of structure solely to the operation of weaving. Density and fastness of texture also vary with the degree of mechanical compression applied to the yarns in the loom; hence the terms "hard" and "loose" woven. With yarns of the same counts or diameter, using a similar weave structure, two cloths may differ in compactness from each other, one being open and the other firm in "make" or build. But this is a difference which only modifies, in degree, that distinctness of threads characterising the loom-felled fabric, which the processes of finishing may entirely obliterate.

Softness and elasticity of texture, freshness of colouring, clearness of weave, and smoothness of surface are wanting in the greasy woollen piece. Finishing changes the cloth in all these qualities. Comparative harshness of handle is due (*a*) to the threadiness described; and (*b*) to the grease and dirt with which the yarns are impregnated. The processes of scouring and shrinking eradicate these textural conditions. Finishing thus, in a general sense, improves woollen fabrics in softness, density, soundness of structure, brightness of texture and design. In specific cloths, such as those milled and raised, finishing produces new qualities, *e.g.*, a fibrous surface, a lustrous smooth pile of fibres, or a dense, velvety pile; and these in fabrics which, when examined in the loom, have an ordinary woven structure and character.

(13) *Worsted Fabrics and Finishing.*

There is an important difference between fabrics made of woollen and worsted yarns, when contrasted unfinished. The worsted more closely resembles the finished fabric, both in structure and appearance, than the ordinary woollen. As shown, the latter is invariably modified in several essential features. This does not necessarily follow in worsteds of the Botany class. Here finish should develop the qualities of texture produced in the loom. A worsted is strictly a loom-felled fabric as distinct from a texture changed in density and other technical features after weaving. The main causes of the closeness of comparison between a worsted unfinished and finished are (1) the relatively clean condition of worsted yarns; and (2) the even, smooth, bright surface they possess, and which the finishing of the fabric should enhance.

Yarn structure is a controlling element in the routine of finish applied to the fabric. Botany and Crossbred worsteds are examples of this, as are also Cheviot and Saxony woollens. In the case of the Botany, the first end to be attained is preservation of the qualities of the yarn; and this at once limits the possibilities of "finish". But if this were not the object, the true worsted, when considered in relation to finishing routine, is not comparable with the typical woollen in fibrous density. Length, quality and fineness of fibre may obtain to a much fuller degree than in the woollen; but the lack of density detracts from the value of the thread for giving a fabric capable of like varied treatment in finishing. Fibrous bulk is essential in the cloth when it has to undergo the processes of milling and raising. The improvement of textural characteristics, rather than the alteration of them, is therefore in finishing worsteds a necessary sequence, and one over which the finisher has only measured control. The ideal "worsted" finish adds to the softness and brightness of texture, and clearness of weave and colouring. It gives a permanent evenness of surface, one in which the qualities of the threads are better "set," and if slightly milled, additional elasticity and fulness of fabric.

In Crossbred worsteds, there is not the same variety of finish as in Saxonies, but it is possible to felt to a considerable degree, and this results in marked changes in the fabric due to finishing. Crossbred worsteds are fabrics in which either a bright or rough surface may be developed after weaving. A Crossbred is distinguishable from a Botany by (1) its crispness of feel and (2) its lack of softness of surface. Rough Crossbred serges are *milled* and not merely *shrunk*. According to the weave structure and the roughness and serge-like effect wanted, they are set from sixty-eight to seventy-five and more inches in the loom for fifty-seven finished. Felting here is obviously comparable to that applied to Saxony woollens, and the results as to weave indistinctness and want of clearness of surface in the texture are similar. But one distinctive feature remains, namely, brightness due to the worsted yarn. In the finer Crossbred cloths, made of fine yarns, and simple in weave, the staple of the wool used is somewhat of a Botany nature, so that the finished qualities, as to smartness and weave precision, approach those of the Botany worsted. The unmilled or slightly shrunk fabrics, comprise costumes and suitings, and are similarly modified in finishing as Botanys. When milling forms a substantial part of finishing, the textural conditions are quite changed, as in heavy Crossbred overcoatings, which are covered with pile similar to a woollen, bright or semi-lustrous in tone. This type of Crossbred is varied in density, elasticity, weight and surface features by finishing.

(14) *Preliminary Work.*

Finishing relates to all the processes to which the fabric is subjected after being woven. Each process does not necessarily effect a change in the fabric. The preliminary operations of perching, knotting, mending and burling are corrective work concerned with the eradication of defects occurring at some stage of manufacture.

The first handling of the piece, after weaving, is done by the percher, preferably in a north light, with the object of detecting faults due to the yarn, imperfect weaving, or irregular action of the loom. The work is comparatively simple, but requires judgment, quickness of sight, and some knowledge of fabric structure. All faults are marked and, as far as possible, repaired before scouring.

Knotting consists in first examining the piece on the under side, the knots being detected by touch as well as by the eye, and drawn by burling irons on to the back of the cloth and carefully removed: subsequently the face is similarly examined. When uneven parts in the yarns have to be taken out, it is done by the mender, new yarns being inserted.

Mending, like knotting, may be done both before and after scouring. Defects are liable to occur even in satisfactorily woven fabrics which require the attention of the mender. Common causes of faults in the piece are broken picks, and want of care on the part of the weaver in picking up broken threads. The finer the fabric, and the more intricate the weave, the more difficult this work. The correct interlacing of the weave structure has to be followed in inserting new threads, whether of warp or weft.

Burling is also a preliminary work. In the union trade, burl dyeing, that is, dyeing the cotton yarn in the piece, is practised, but in the woollen trade, burling is the operation of removing specks of vegetable matter, such as broken burrs, which have remained in the wool through the processes of carding and spinning. In pieces composed of cotton and wool, in which the yarn, either warp or weft, may be Angola, the cotton may be stained by applying to the surface of the cloth a diluted solution of ink. This is done in the inking machine, Fig. 2, where the piece passes round guide rollers and over roller C. The lower roller A revolves in the trough containing the solution, so that

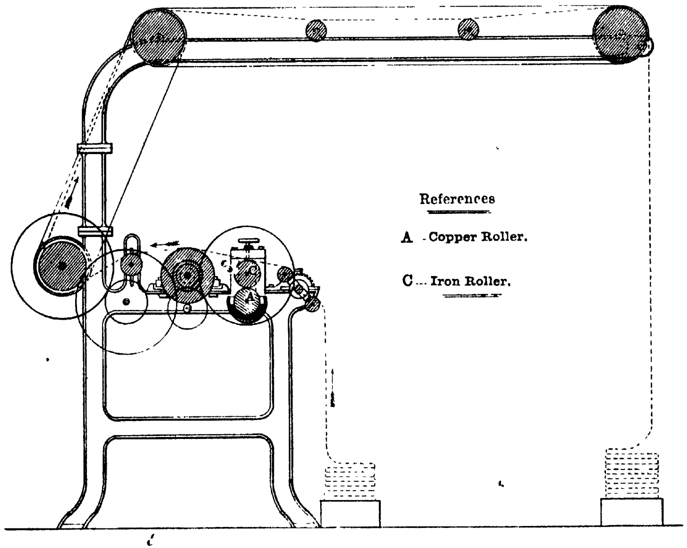


Fig. 2.

the upper roller carries some of the solution from A on to the fabric. The piece now passes over a revolving brush and round suitable guide rollers overhead, as shown. This process is repeated until a sufficient quantity of ink has been applied to colour the cotton. The stain more effectively penetrates the yarn if the pieces after inking are taken to the brushing machine or mill, and brushed on both sides in succession, first without and finally with steam. Woollen fabrics, in which there is a quantity of vegetable matter, broken burrs, etc., are carbonised, that is, placed in a bath of diluted sulphuric acid, and then dried at a high temperature.

(15) *Finishing Processes.*

Finishing processes (after the preliminary work described) comprise scouring, hydro-extracting, tentering, milling or felting, raising, cutting, napping, blowing, crabbing, boiling, dewing, brushing, steaming and pressing. The routine is divided into three departments, namely, the scouring and milling or *wet* processes; raising and boiling for woollens, crabbing and brushing for worsteds; and the cutting, pressing and steaming, or *dry* processes. In the factory these are natural divisions, there being a foreman for each section. For another reason they are kept separate; the nature of the work is so different and can be more accurately controlled when in the departments named.

In these sections no mention is made of tentering, which again is separate and in a convenient part of the mill for obtaining steam for drying purposes.

(16) *Scouring and the Detergents Used.*

The pieces having been perched, knotted and mended, are ready for scouring, the object of which is to thoroughly cleanse the cloth from grease and other impurities. Loom qualities possessed by the fabrics, namely, harshness of handle and threadiness, should be removed, and softness and loftiness of touch imparted, leaving the colours clear and bright, and with the surface of the fabric free from creases. During scouring, the fibres and threads are compressed into closer contact with each other. The pieces, when impregnated with soapy lather, are in a condition favourable to felting; but felting should not form an essential part of scouring, though some allowance is made for shrinkage of woollen pieces in this process when determining for the finished width.

Piece scouring, like that of yarn and wool, is a chemical and mechanical process. A German system, in which experiments are being made, consists in extracting the grease and dirty matter by means of electricity. The pieces run in a continuous length and full width from end to end of the machine. In the first place, the pieces enter the tank containing the liquor charged with electricity, then pass between squeezing rollers and into a second tank containing water for washing off. Here, the pieces pass to the bottom of the tank, round guide rollers, then between pairs of squeezing rollers, the process being repeated several times.

The principal detergents used in the ordinary methods of scouring are fuller's earth, soap and alkalies (soda and potash), and special compounds such as soap ash. Fuller's earth is suitable for washing after dyeing, as it removes any particles of dyeware.

If vegetable oils, olive or Gallipoli, have been used preparatory to carding, as these oils do not readily saponify, they have to be removed from the piece by emulsion, and soap and an alkali are used for this purpose. When olein has been the wool lubricant, it is possible to scour the cloth by means of an alkali only; about 20 lb. of soda ash or 30 lb. of pearl ash will saponify 100 lb. of olein or fatty acid. Standardisation is desirable in scouring solutions. This is done by combining a fixed percentage of soap and alkali with given volumes of water; as, for example, 5 lb. of curd soap with 3 gallons of water, and 2 lb. of potash with the same volume of water. The degree of alkalinity should be higher in heavy greasy cloths, and lower in comparatively clean fabrics and in pieces in which bright colours occur.

Soaps as near neutral as possible are the most useful for both scouring and milling. A soap containing more than 0·75 of free alkali should not be used. The following are analyses of hard and soft soaps of good scouring properties.—

	Tallow Soap.	Curd Soap.
	Per cent	Per cent.
Free Alkali, NaOH .	0·16	0·40
Combined Alkali, Na .	5·75	5·75
Fat	69·19	64·85
Moisture . . .	24·90	29·00
	100·00	100·00

POTASH SOAP.

	Per cent.
Free Alkali, KOH	0·156
Combined Alkali, K	8·307
Fat	44·400
Potassium carbon	3·657
Moisture	43·480
	100·000

Soap-ash compounds, which are used for scouring goods in which olein has been applied to the materials prior to carding, are composed of sodium carbonate and water, in the form of soda crystals, with soap, as seen from the analyses below:—

I.

	Per cent.
Sodium carbonate	26·818
Water	70·300
Soap	2·882
	100·000

II.

	Per cent.
Sodium carbonate	36·464
Water	58·800
Soap	4·736
	100·000

In washing fancy fabrics strong alkalies should not be used, as they have an injurious effect on bright colours, causing them to run or bleed. Excessive alkalinity of the scouring solution also tenders the fibres and lessens the elasticity of the fabric. Dulness or want of tone in the colours and of the fabric may be produced (1) by imperfect washing off; and (2) by the "scour" not having neutralised the greasy matter in the cloth.

(17) *Hydro-extracting.*

After washing off, if the hydro-extractor is not used, the pieces are passed through the wringer before tentering. The wringer is made in two forms, with one or two pairs of rollers. In the latter machine, the lower roller of the front pair is flanged, and the back pair without flanges are covered with indiarubber composition. The speed of the rollers varies from 90 to 100 revolutions per minute.

The hydro-extractor is another method of expelling the moisture from the piece. It consists (1) of the outer case work, and (2) of the metal basket or cage, which may be either on fixed or elastic bearings, and speeded to make from 1,200 to 1,500 revolutions per minute. When the machine has been loaded, by evenly distributing the piece in the twisted condition round the cage, the centrifugal velocity expels the water through the perforations of the cage, and leaves the piece in an open, free condition. On this system there is little possibility of the fabric being creased, as might be the case with the use of the wringer in pieces made of Crossbred worsted, mohair and lustre worsted yarns.

(18) *Tentering and Drying.*

At this stage the pieces should be measured in width and length, so that the shrinkage may be fixed for milling. Tentering may at once follow; it straightens the piece for subsequent work. This may be done on the hand tenter bars or by machinery. Tentering in the open air on tenter bars, or natural drying, imparts a better condition to the cloth, the fibres being softer and the texture fuller in the handle, hence the preference in the blanket trade, wherever possible, for open-air tentering.

The usual form of automatic tentering for woollen and worsted cloths is shown in Fig. 3. The piece enters the machine from a raised table, A, being hooked on to the tenter chains at each list, and passes from the upper to the lower tier of steam pipes in succession, being delivered by an ordinary folding mechanism, D. The machine possesses a superheater for utilising the hot air instead of an ordinary exhaust fan which is employed in other machines. The number of tiers may vary.

Another method of hot-air drying is adopted in treating certain classes of rugs, imitation sealskins, astrakhans and other pile fabrics, vertical tenter bars or frames being used for this purpose. An installation of this kind is shown in Fig. 4, and consists of an air heater and two fans. These distribute the hot air, at a temperature of 120° F., through pipes which extend the length of the room, and have frequent outlets so that the air penetrates the pieces. The tentering room can be cooled in a short time by closing the hot-air outlets and admitting cold air, to allow the workers — if pile fabrics are being treated — to beat the pieces on the underside to force the fibre out of the foundation of the fabric.

In a second system of this character, adapted to the drying of woollen and worsted cloths, the pipes are fixed in the floor or a little above it, the fan drawing the heated air through the pieces which are hung on rails. If needed, valves are provided so that the warm air, when sufficiently dry, can be circulated back through the fan and re-heated, obtaining a high tem-

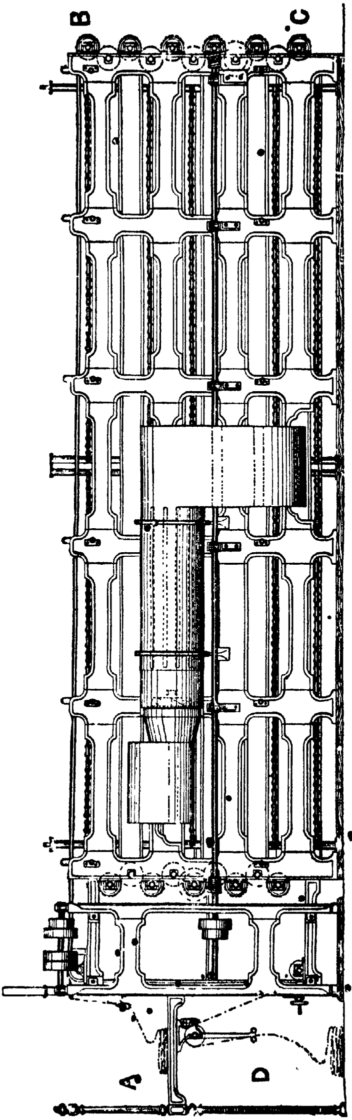


Fig. 3.

perature by an economic use of steam. With either installation, by having separate connections to each section of the heater, the temperature of the air can be readily regulated.

After the process of tentering, if the piece is a woollen, it is covered with loose or balk fibre which has developed on the surface. This fibre is a valuable quantity in milling. Whatever the yarns or materials used, tentering imparts a dry and somewhat unnatural handle, but this is removed by subsequent processes.

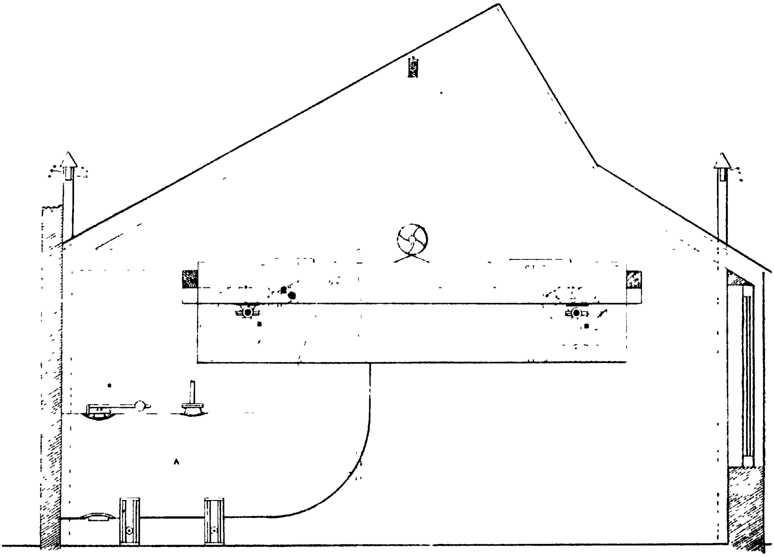


FIG. 4.—Section of a tentering room with air heater and revolving fans.

A = *Superheater.* B = *Revolving fans.* C = *Regulating valve.*

Pieces lose weight in tentering, not only by the evaporation of the moisture they contain after hydro-extracting, but by drying to such a degree as to take off a percentage of the humidity which the material naturally absorbs. This weight the fabric regains in normal atmospheric conditions.

(19) *Felting and its Effects.*

The power of contraction of a woven fabric is primarily due to the fulling property of the wool, which is the source of more radical change in finishing than any other quality in the material. It modifies the fulness, elasticity and wearing strength or durability of a woven fabric, and also produces certain textural characteristics which render diversity of finish feasible in woollen and other fabrics.

Density of texture due to felting or fulling differs in degree and nature from the compact union of threads, the result of weaving. Porousness and looseness of structure are substituted by fibrous homogeneity, in the process of felting. Literally, to full or felt is to add to the thickness or substance, but to reduce the length and width of the piece. Even if the fibres in a woollen fabric had a smooth surface, they would, in the routine of yarn manufacture, entwine and form entangled meshes. Fulling is more than this It is the compression into a dense mass, of threads separately interlaced, and of the fibres of which they consist. Contact is succeeded by cohesion of fibres. The fibrous change is of a physical and chemical nature, the chemical action of the soap or fuller's earth applied to the piece originating conditions which are necessary to fulling. The threads are rendered more pliable and the fibres softened by reason of their hygroscopic properties. Contraction in the piece is progressive throughout milling, the individual fibres gradually filling up the interstices which are such a feature of the scoured cloth.

(20) *Condition of the Piece in Milling.*

The piece may be milled before or after scouring. The former is termed "raw-thread" milling, the piece being in the greasy state, and is practised when softness as distinct from firmness of fabric is desired.

When milling follows scouring, the pieces, after hydro-extracting, may be cuttled up and allowed to rest for a period, or, in light felting, immediately placed in the milling machine. Evenness of soaping is most important. Should some parts of the fabric be more freely treated than others, irregular felting will ensue, and possibly develop flakes or patches. There are two methods of preparing the pieces for milling: (1) by applying the soap and placing the pieces for a short time in the stocks; (2) by running the pieces through the lecker or soaping machine. This machine consists of a trough containing a standard fulling solution, entering which the cloth passes under guide rollers immersed in the soap, and then through a neck to a pair of squeezing rollers. The quantity of solution carried off by the fabric is regulated by the pressure applied as it passes between the rollers. An excess of soap induces the pieces to slip too freely between the compressing parts of the milling machine, and gives sponginess of handle, whilst if the quantity of soap is insufficient, a waste of fibre ensues, and the period of felting is unduly prolonged. The proper condition is one of uniform soapiness without the formation of a lather. There should be indications of the soap on the surface without a tendency to scour. The action of the fatty matter in the soap imparts pliability to the fibres and smoothness to the surface of the fabric, diminishing the quantity of flocks produced by the constant friction in fulling.

(21) *Potash and Soda Soaps.*

The shrinkage of wool, in whatever period of manufacturing,—*i.e.*, in layers of carded fibres, the spun thread, or the woven fabric,—is caused by applying to the material a solution of soap or fuller's earth. A portion of the soapy compound is held in the interstices of the threads, and a portion absorbed by the fibres. As, however, this process of absorption commences and continues when the pieces are under compression, the area in which the fibres are lodged being diminished, impels them into closer contact with each other.

The nature and chemical composition of the soap applied to the piece affects the process of shrinkage. The relative value of potash and soda soaps on Cheviot and Saxony yarns in several weaves and settings is stated in Table I. By using a cotton warp in the fabric, the contraction in length is almost *nil*, so that the comparison is distinctly upon the woollen yarns and in the direction of the weft. The conditions as to pressure in fulling, temperature and periods of milling, are identical in each case.

The analyses of the two soaps in which these comparisons are made are as follows:—

POTASH SOAP.	Per cent.	SODA SOAP.	Per cent.
Combined alkali, K	8·97	Combined alkali, Na	5·30
Free alkali, KOH	traces	Free alkali, NaOH	0·50
Fatty acids	43·50	Fatty acids	59·72
Water	47·53	Water	34·48
	100·00		100·00
Actual percentage of soap, 52·47 per cent.		Actual percentage of soap, 65·02 per cent.	

The milling results are stated in four periods, after the pieces have been in the machine 30, 60, 90 and 120 minutes.

The fulling period not only alters the measure of shrinkage, but when two or more wools are combined of different felting properties, it produces other effects in the piece. Table I., however, indicates mainly the difference in the behaviour of the two wools, Saxony and Cheviot, in the periods named. In the first period, the highest felting in each weave is with the hard soap; in the second period with the potash soap, and the increase in felting is maintained with the potash throughout the third and fourth periods, showing that if rapid and light shrinkage is needed, the soda soap is preferable; but if heavy shrinkage, continuing for some time, then the potash is the more satisfactory.

Taking the plain weave and the $\frac{2}{2}$ twill, the following are the felted results from a piece 31 inches wide in the loom:—

TABLE II.

POTASH SOAP.

Milling Periods	Plain Weave.		$\frac{2}{2}$ Twill.	
	Saxony.	Cheviot.	Saxony.	Cheviot.
I. Period	20½″	25″	20″	22½″
II. ,,	20¼″	21½″	17″	17″
III. ,,	19″	20″	16″	16½″
IV. ,,	18″	19½″	15½″	16″

SODA SOAP.

Milling Periods	Plain Weave.		$\frac{2}{2}$ Twill.	
	Saxony.	Cheviot.	Saxony.	Cheviot.
I. Period	21½″	24″	19½″	21¼″
II. ,,	20½″	23½″	19″	20¼″
III. ,,	20½″	22″	18″	19″
IV. ,,	19¼″	20½″	17″	17¾″

In both counts of yarns and weaves the results correspond in the two soaps, that is to say, more shrinkage in the potash than in the soda after the first period. Compare, for example, the shrinkage in the $\frac{2}{2}$ twill, Period IV., the piece having shrunk to 15½ inches with the potash soap, against 17 inches with the soda in the Saxony; and in the Cheviot, to 16 inches (potash) against 17¾ inches (soda)

(22) *Effects of Raising.*

Raising has various effects on the condition and appearance of the fabric. A vertical or a laid pile of fibres may be produced: if the former, it is termed a "velvet" pile, and if the latter, a "dress-face" pile. A third kind of surface consists of a short, full, fibrous pile, such as obtains in a typical melton.

The nature of the pile producible and the degree in which it alters the characteristics of the cloth is seen in Figs. 7 and 8. Fig. 5 is the fabric as it leaves the loom: Fig. 6 after scouring and milling; Fig. 7 after raising the cloth damp. The difference in the conditions of these three fabrics is very marked. The prominent features in Fig. 5 are the clear twills, whether in white or colour, and the distinctiveness of the threads, warp or weft; in Fig. 6 the twills are subdued, and the warp threads concealed, the surface of the cloth having become more fibrous, and the individuality of the threads less distinct

Raising causes the effects seen in the fabric, varying in degree and in the manner in which the fibres are spread. That is to say, the fibre which develops in felting is drawn or laid on the surface of the cloth. This should result without the individual threads—which resist the action of the raising points, whether teazles or card clothing—being disturbed.

In Fig. 7A is shown a number of the weft yarns which have been removed from the fabric. These retain their adhesiveness and have a similar appearance as the fabric proper, showing that milling and raising have caused the weft yarns to adhere to each other. If withdrawn from the loom-felled fabric, Fig. 5A, they have no such affinity. From Fig. 6A it is clear that the picks hang together prior to raising, without the warp; the drawing of the fibres from one pick to another in Fig. 7A causes

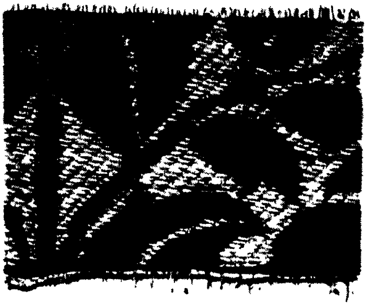


Fig. 5.

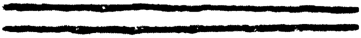


Fig. 5A

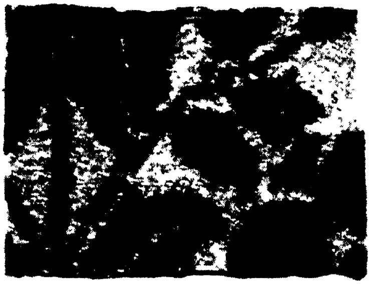


Fig. 6.

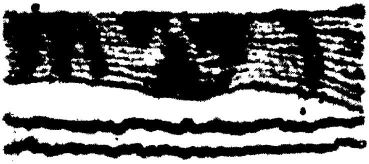


Fig. 6A.

the materials in the successive picks to overlap each other, forming a continuous fibrous pile.

The distinctive features given to the cloth by raising are (1) fibrous surface; (2) increased softness and fulness of handle;

Fig. 7.

Fig. 7A.

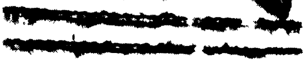


Fig. 7B.

Fig. 8.

Fig. 8A.

Fig. 8B.

(3) concealment of the threads and weave effect; and (4) subduing of the colours and softening of the outlines of the pattern. As to the strength and elasticity of the cloth, these suffer if

raising is excessive, and if done when the cloth is in too dry a condition. The process should not, however, impoverish the cloth of fibre, nor so disturb the fibres of the threads, of either warp or weft, that the elasticity and strength of texture are diminished.

(23) *Influence of Textural Conditions on Raising.*

First, in regard to the surface of the fabric. This should be firm and close when more than light raising is essential. The greater the degree in which the work has to be done, the sounder and closer the structure of the fabric, whether due to weaving, felting or both. If a full pile of fibres has to be obtained, there must, in addition to the closeness of threads resulting from weaving, be a "balk" or fibrous quality developed in felting. It is this difference in the surface of fabrics which is the primary cause of the variation in the raised conditions. Comparing, for example, the surface of a worsted texture with that of a hard-felted woollen, the latter is exactly of the kind to be suitable for raising and the former the reverse. To treat an unmilled worsted with the raising points of the teazles, would immediately disturb the fibres of the threads which it is the object of finishing to preserve, and this follows, because of the absence of loose, extraneous filament in a smooth thread of uniform structure. In the woollen yarn there is a fuller quantity of fibre, diameter for diameter, as compared with the worsted, and there is also more balk fibre on the surface of the yarns, which felting secures to the fabric, so that straightening and combing out of the pile is rendered possible without detaching the filament.

There are three technicalities which modify the surface of a woven fabric in relation to the process of raising, whether made of woollen or worsted yarns, namely: (1) fineness or quality of the materials; (2) structure of the yarns as to degree of twine; and (3) the structure or build of the fabric.

Obviously, the nature and quality of the wool influence the possibilities in raising. To obtain a short dense pile a finefibred wool, possessing a full, short staple, must be used; but if the pile should be of a blankety character, longer, coarser and less dense, then wools of a strong, more open staple, such as East Indian or Shetland, would give these qualities by raising. What applies to pure wool fabrics is also applicable to union textures made of mungo or shoddy; mungo, being the shorter and finer staple, is suitable for fabrics on which a pile may be raised similar in character to that of a beaver cloth; but shoddy, for fabrics in which a longer pile is required, or for the under side of union worsteds raised to give the cloth a fuller handle.

It will be readily understood, the harder a woven surface the greater the difficulty of raising. Hardness of texture is produced by firmness in weaving, by the measure of felting, and by the number of turns per inch in the yarn. Yarn doubling also minimises raising facility in the fabric, two or more threads folded together offering increased resistance to the raising points. On whatever principle the yarn is constructed, twine, greater or lesser in amount, changes the raising surface of the texture. An example of this is found in a union fabric with a mungo weft, which makes a surface that raises well and quickly to a certain degree of fulness, beyond which the resultant pile is soon impoverished owing to the short and inferior nature of the material. The weft yarn here being extremely soft in twine—only possessing a sufficient number of turns to form a weavable thread—is the primary cause of the raising quality. Fabrics of the whipcord class, in which raising only produces a surface pile, are examples of the effect of hardness of twine on raising. In these, though the material may be of a much finer character than in the mungo cloth, yet on account of the firmness with which the fibres are twisted together there is a want of raising essentials.

(24) *Theory of Raising and the Twine in the Yarn.*

There is another important definite relation between the raising quality in the woven fabric, as affected by the twine in the yarn, and the number of turns in a given length, namely, the direction in which the threads in the cloth are acted upon by the teazles. This may be either transversely or longitudinally, the character of the pile being modified by the nature of the action. If the face of the fabric consists of the weft yarn, and raising is done in the direction of the warp, the teazles, coming in contact with the sides of the threads, more rapidly produce a pile, but it is rougher in the foundation of the texture than if the surface of the cloth were warp and the raising points travelling in the line of the length of the thread. To obtain equal raising action, transverse and longitudinal, on the yarns, the build of the fabric has to be such as to give alternate and equal interlacings of warp and weft on the surface.

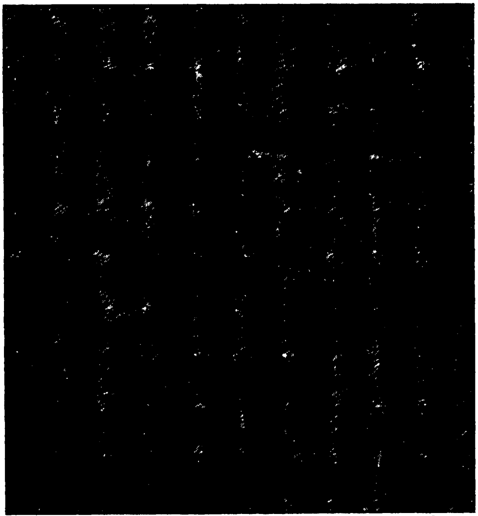


FIG. 9.

(25) *Fabric Structure and Raising Surface.*

In raising from end to end of the piece, there are three distinct types of woven surface in regard to the direction of contact of the raising points with the yarns, namely: (1) Fabrics with a weft surface; (2) fabrics with a warp surface; and (3) fabrics with a warp and weft surface.

These three textural surfaces are shown in Figs. 9, 10 and 11. The direction of the raising point in traversing the cloth is indicated by the arrows. In Fig. 9, raising is across the thread forming a rough shag of fibres on the sides of resistance (see Fig. 7B). Naturally such action freely disturbs the normal relation of the fibres if the raising contact is severe. It is not an economical method of producing a full, close pile, in which the fibres have actually to be "raised" out of the threads. It is less detrimental in cloths made of yarns possessing a raising quality of extraneous filament.

The action on the yarns is kinder in Fig. 10, being lengthways of the thread, so that the raising points move in a line with a larger average of the fibres, and gradually comb them in the same direction. The condition of the yarns from Fig. 7 and Fig. 8 (Figs. 7B and 8B) after treatment by the two methods, shows that cross-thread raising may even destroy the continuity of the thread or reduce its fibrous compactness to breaking point, whereas raising in the direction of the yarn leaves it sound and straight. This is remarkable when the relative fulness and quality of the pile in Figs. 7 and 8 are compared. That in Fig. 7 is a degree fuller in the foundation, but there is a want of evenness of length of fibre so essential in a good pile. "Cross-thread" raising acts immediately on all fibres, long and short, on the surface of the yarn, producing a pile in a brief period, but one characterised by inequality of length. On the other hand, raising lengthways of the yarn first lays and straightens the long fibres, and more gradually acts upon the shorter ones, hence a more level fibrous surface. Obviously, if a full handling cloth is the chief characteristic wanted, cross-thread raising is satisfactory; but if this quality is required, combined with evenness and brightness of pile, then raising in the sense of the length of the thread is preferable. It should, however, be observed that the difference between these two distinctive principles of raising may be lessened by the nature of the yarns used and the amount of felting. The finer the yarn, and the larger the number of threads and picks per inch, the more felting and the greater quantity of "balk" fibre produced. In other words, if felting be continued until the yarns are "burst," the fibre resultant is more closely the same in character for raising purposes, whether due to the weft or the warp yarns. For instance, assuming the surface of the cloth to be as in Fig. 10 (warp-face sateen),

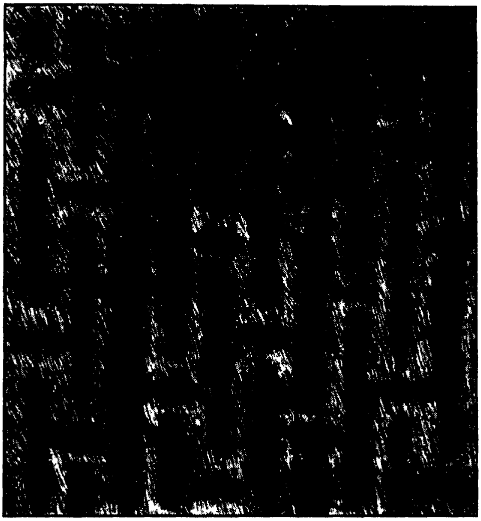


FIG. 10.

and made of the same yarns as Fig. 9 (weft-face sateen), then, by heavy felting, the threads are so matted together as to form in each texture a surface of similar qualities for raising; that is, a layer of filament which may be treated before any new fibre is raised out of the yarns. But if the process of getting up the pile continues until the actual surface of the yarns is affected, the conditions defined in relation to the raising of fabrics, Figs. 7 and 8, are developed.

The third type of woven surface, Fig. 11, allows of an equal degree of transverse and longitudinal raising on the threads, cross-thread raising on the weft and the reverse on the warp, or *vice versâ*, according to the character of the operation. This is the woven surface which gives quality to the pile of the plain "super" and the highly-finished billiard cloth, namely, the combined effects of raising on the length and across the yarns, warp and weft. There is obtained in this way the closest and fullest pile possible.

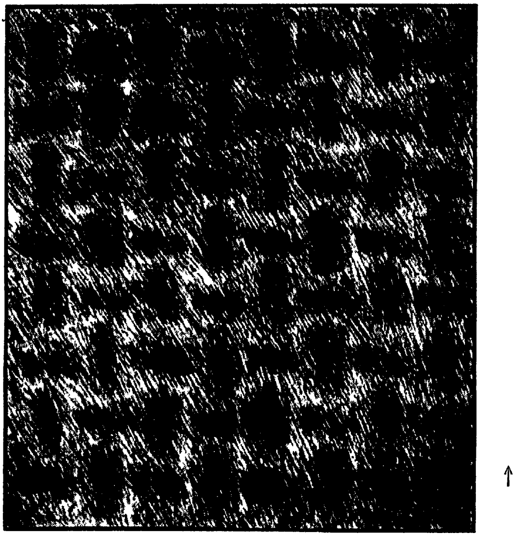


Fig. 11.

An element affecting this compound raising is the direction of the twine in the warp and weft. In Fig. 11, it appears the same in both yarns in the cloth, due to the weft being at right angles to the warp; but in Fig. 12, the weft appears the reverse of the warp, and is so in relation to raising contact. Clearly, in Fig. 11, the points of the teazles would act upon the fibres of both yarns as nearly as possible at the same angle. The only difference would be side action on the weft and the lengthway action on the warp. The direction of the fibres, whether of warp or weft, in relation to the movement of the teazles through the surface filament of the cloth, would be the same providing the turns per inch were identical in each yarn. On the contrary, in Fig. 12, the resistance of the twine of the fibres would alternate from warp to weft, producing another technical feature capable of modifying the nature of the pile obtained.

In contrast, a woven surface with the twine in the yarn, as in Fig. 11, raises straighter and more level: but a greater degree of fulness of fibre in the foundation of the fabric results when the warp and weft are reversed in twine, as in Fig. 12.

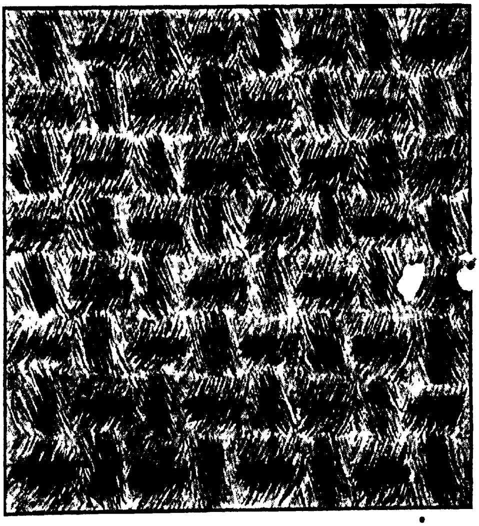


FIG. 12.

(26) *Several Kinds of Raising: Dewing.*

Ordinarily, raising takes place after milling, but if it immediately follows scouring—"raw-thread" raising—it produces a pile of peculiar softness. When felting thus succeeds the raising process, it covers the weave with fibre and eradicates threadiness without rendering the fabric too firm and stiff in the handle.

"Cross" raising consists in treating the piece from list to list. By raising the cloth from end to end and then across, the density of the pile is improved, both warp and weft being operated upon transversely, and in the direction of their length.

To add to the raising properties of the wool, water is applied to the pieces, and this is known as the "wet" process. Cloths are raised in a normal state of dryness with the object of getting up the surface filament. Clear-finished fabrics are generally raised dry, the work being mild in character.

Raising moist or wet both preserves the fibre and renders the wool more flexible, making it feasible to raise a full nap with a minimum loss of "flock" or filament. All fabrics in which the fibrous pile is a distinguishing feature of the finished condition, undergo the wet process of raising. The degree of dampness depends upon the quality of the materials of which the fabrics are made, and the density of nap producible. In the harder, stiffer materials, *e.g.*, unions, the pieces are quite wet in certain stages of raising; this is also the case in woollen doeskins in the early part of the routine, improving the action of the raising points on the threads. Velvet pile cloths and "soft-finish" fabrics—with a slight draw of fibre on the surface—are, on the other hand, raised in the damp or moist state.

Whatever the condition of dampness, it should be uniform throughout the piece, or streakiness develops. The dewing machine may be used for this purpose, or the water may be sprinkled on the pieces during raising. One useful form of machine consists of a trough or tank containing the water, and a circular brush, which revolves in the same, sprays the water on to the piece. This is a simple and effective method. Another form, really a damping machine, consists of a trough, with a large rubber covered roller, and two upper rollers placed above the main roller. The former revolves in the water in the trough, the height of the water being fixed according to the degree of dampness required on the piece. The upper part of this roller is not immersed in the water, but the piece passes over it, being pressed in contact with it by the two smaller rollers. Dewing is also done to restore condition in the cloth after excessive dryness, and improves its handle.

(27) *Lustring Processes.*

Brightness of surface in a woven fabric may be due (*a*) to the natural qualities of the wool; and (*b*) to the methods of finishing. In Sicilians and glacés—dress fabrics with a cotton warp and mohair weft—lustre is a pre-eminent quality of the fibre, enhanced by the treatment the fabric undergoes in such processes as cleansing, cutting, singeing and pressing. But in a union beaver or a similar cloth, with a cotton warp and mungo weft, brightness is artificial, not being a perceptible quantity in the raw material. In dress-face woollens and fine piece-dye worsteds, the lustre of the finished fabric is higher than in the wool in the natural state.

Lustre is developed in textile fabrics by (1) the mechanical adjustment of the fibres in (*a*) yarn construction, and in (*b*) raising; and (2) by subjecting the pieces to high temperature and pressure. Lustring processes include raising, boiling, crabbing, blowing and pressing.

The lustre due to yarn construction—the result of combing the wool prior to drawing and spinning, and so distinct from that developed in the woven fabric by finishing—suggests the principle underlying all surface brightness in a fabric made of wool, namely, parallelism of fibres. The more this can be secured, whether in yarn manufacture or in raising, the higher the lustre of the texture. Still, neither the combing of the wool, nor the straightening action in raising, so much impart lustre as produce fibrous conditions favourable to the display of such natural brightness as the wool possesses. Both combing and raising straighten the separate fibres and draw them in a line with each other. But the processes of boiling, blowing, crabbing and pressing, both develop and fix the fibrous lustre. Boiling is practised in woollen finishing. Crabbing is a compound process of boiling for a short time, and steaming, and has a similar effect on worsted fabrics to that obtained on dress-face woollens by boiling.

The pieces, being tightly stretched when subjected to these processes, are straightened and levelled on the surface, all creases and similar inequalities being totally eradicated. The work secures a thoroughly even, straight fabric before dyeing. It is also done before scouring in Crossbred pieces, which so readily "rig," or develop creases in this operation and milling.

Whatever conditions remain in the pieces after blowing or crabbing are all but permanent. Steaming the pieces under this high tension adds lustre to the fibre, smoothness to the yarns, and smartness to the texture; but at the same time, if the pieces are not perfectly clean, if they are specked or stained, or if not under a uniform tension from end to end and list to list in winding on, defects will arise that it is almost impossible to remedy.

(28) *Pressing.*

Pressing is the final process in finishing, and has a twofold object, namely, to give permanent evenness to the fabric, and to enhance its lustre. Cloths which have been crabbed and boiled may be wanting in firmness and brightness; while those which have not are comparatively loose and spongy, and readily show signs of wear. Straightness of surface and clearness of texture are only partially developed in the preceding routine of finishing; but they are rendered permanent in the pressing operation.

The pieces are treated at an ordinary temperature or with heat—"hot" and "cold" pressing respectively. The cold process is applied when little "press" is required or to fabrics where weight alone is sufficient to produce evenness of texture.

The heat generated in hot pressing, and time occupied, varies with the nature of the cloth and the kind of finish to be obtained. In pressing rough Cheviots—where the natural qualities of the wool should be retained—neither much heat nor pressure are needed; but in Saxonies, worsteds and unions, a temperature of 104° to 112° F. is common, with 3,360 lb. to the square inch.

Cold and hot pressing differ in the conditions they produce in the fabric. Wool is rendered more flexible and more susceptible to mechanical treatment under (1) a high temperature, *e.g.*, in combing in worsted yarn manufacture; and (2) by humidification, *e.g.*, in raising. It follows that pressure applied to the cloth in normal conditions as to moisture and heat, has little effect beyond saddening the surface. The extraneous filament remains prominent on the face of the fabric, not being laid or forced into the threads of the cloth. In each of the four typical all-wool textures—Cheviots, Saxonies, Crossbreds and Botanys —the difference in the firmness or soundness between fabrics "hot" and "cold" pressed is distinctly marked. A Cheviot hot pressed improves in brightness; the fibres protrude in a much less degree from the face of the fabric; there is closer cohesion of the yarns, and the spaces between the threads are reduced by the loose fibre being pressed into the surface of the cloth. On the other hand, the same weight applied without heat leaves the threads with less adhesiveness to each other; the fibres loosely projecting on the yarns; the textural threadiness more marked and the handle rougher, but the natural quality of the wool in this respect better preserved. On this ground, cold pressing, not imparting artificial qualities, is preferred in the finishing of "homespuns" and rough tweeds.

Similar points of difference, but more pronounced, obtain between a Saxony pressed with, or without, heat. The characteristics of the cold-pressed cloth are deficiency in firmness and smoothness of handle; the texture too spongy and elastic, possessing an undesirable fibrous roughness. The same cloth under similar pressure, but a higher temperature, becomes bright and firm.

An ordinary Crossbred of a clear weave structure, after cold pressing, is only slightly changed, the thready ridges of the twills being clearly visible, the surface loose and open, with an absence of compactness of structure; but if heat is applied, a smooth surface results, and a fabric in which the rigidness of the twills is obliterated without over-subduing the weave effects, and one in which the yarns have, to a much higher degree, the property of cohesion.

Fine Botany worsteds, before pressing, are bright and clear on the surface, and hence cold-pressing would effect no perceptible improvement. It is only by the addition of heat, and the humidity in the piece, that the lustre, smoothness and soundness of fabric are enhanced and made more permanent in nature.

Neither heat nor pressure, applied separately, have the effects on the fabric which are known to develop in the press. The moisture or humidity which arises at the commencement of hot pressing, assists in softening the threads and fibres, so that they are increasingly susceptive to the conditions induced by pressure. But the essential distinction in pressing with and without heat, is the expansion and contraction of the wool fibres, occurring during heating and cooling in the former, and which are not present in cold pressing. These are changes affecting the fibres rather than the yarns. In other words, the threads are partially collapsible under continued pressure, but this is not, to the same degree, characteristic of the fibres. At the same time, as the yarns yield to compression, the cells constituting the principal part of the fibre expand, induced by the humid conditions obtaining. Such dilation of the spindle-shaped cells, with the cloth under high pressure, flattens the outer scales, causing the fibre to more closely resemble, in external structure, mohair. Yarn compression adds to the compactness and firmness of the texture; fibrous expansion, with compression of the external scales, produces brightness of surface. These qualities are fairly permanent. If the cloth is "glazed," steaming softens the threads without removing the brightness developed, or affecting the smoothness and straightness of the textural surface.

CHAPTER III.

THE PROCESS OF SCOURING: SCOURING MACHINES.

(29) Impurities in Greasy Pieces. (30) Scouring Machines. (31) The Rope Machine: Scouring Operation. (32) Washing-off. (33) Points in the Use of the Rope Scourer. (34) The Open Scourer: Construction. (35) Advantages of the Open Scourer. (36) Scouring Machine with Flanged Roller. (37) Combined Scouring and Milling Machine.

(29) *Impurities in Greasy Pieces.*

WOOL is impregnated with from 20 to 60 per cent. of impurities chiefly consisting of fatty matter or suint. These are removed in the processes of washing. Yet in this non-greasy condition wool could not, without injury to the staple and wasteful results, be carded into a fleecy web of uniform consistency. A lubricant is necessary to preserve the natural length of the fibres, and also to facilitate the opening, blending and combing operations on the various cylinders of the carder. As a result of this application of oil to wool, some 15 to 20 per cent. is added to its clean or net weight, accounting in woollen manufacturing for a corresponding loss of weight in the scouring of the spun yarn or woven piece. The ordinary processes of manufacture do not add, to any considerable degree, to the percentage of impurities in the cloth. The passing of the material through the operations of carding, combing, spinning, winding and weaving, and other work in which it is handled, must affect its clean condition; but it is the oil applied to the wool prior to carding that renders the difference so appreciable, in some classes of woven manufactures, between the weight of the loom-felled and scoured pieces. Worsted fabrics, for example, in the yarn production for which little or no lubricant may be used, do not, on the average, lose in scouring more than 5 to 7½ per cent. On the other hand, in mungo and shoddy manufactures, the loss may attain 35 per cent., due to the oil applied to the rags for grinding and carding, and to the impurities the rags may contain.

The decrease in weight of pieces in washing or scouring is generally proportionate to the following:—

(1) The character of the yarns, such as worsted or woollen.

(2) The materials used—wool, mungo, shoddy, extract, cotton, etc.

(3) In union fabrics, the nature and quality of the several yarns, such as woollen and worsted, cotton and woollen, worsted, cotton and woollen.

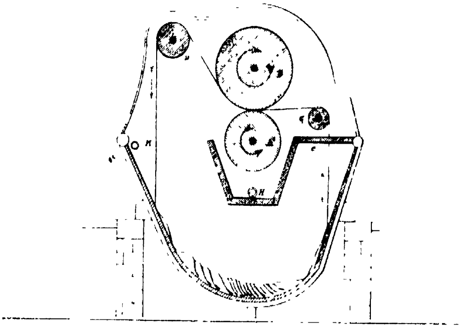


Fig. 13.

Assuming, for example, that a piece is made of three materials, cotton, worsted and woollen, then in calculating the weight, the approximate estimated loss which would result in scouring, on each material, would be taken separately, about 2 to 3 per cent. for the cotton, 7½ per cent. for the worsted, and 20 to 25 per cent. for the woollen. Or, if a cloth were composed of worsted warp weighing 20 lb. and woollen weft 30 lb., a total in the grease of 50 lb., in estimating the clean weight, if 20 per cent. were deducted from the woollen and 7½ per cent. from the worsted, the approximate total would be 43½ lb.

(30) *Scouring Machines.*

These machines are of four distinct types:—

(1) The ordinary rope scourer.
(2) The open or full-width machine.
(3) The scourer in which the lower roller is flanged.
(4) The combined scouring and milling machine.

Each of these machines is used for special purposes. The first type is adapted for the scouring of woollen and heavy greasy pieces; the second, for worsteds and fabrics in which it is necessary to keep the cloth straight; the third, for heavy low woollen fabrics, where the percentage of grease and other impurities is high, and in which as much pressure as possible has to be applied to the squeezing rollers, to expel such matter; and the fourth type for fabrics in which only light milling is required.

(31) *The Rope Machine: Scouring Operation.*

In all scouring machines, the process consists in running the pieces in succession through the alkali or soap solution, and between a pair or pairs of squeezing rollers. The pieces collect in cuttles or folds (see Figs. 13 and 18), or in a form inducing thorough saturation, in the trough containing the scour or lye; they then pass in a continuous length to the squeezing rollers. The process is similar to soaping a length of material and placing it in the scour by hand, holding it there for a time, then withdrawing it and expelling by pressure tne solution which it has absorbed. To simply run the pieces into and through the scour is insufficient, there must be immersion followed by such mechanical pressure as will expel the lye from the fabric. Immersion softens the materials or yarns in the cloth and assists the soapy solution to liberate the dirt and grease, whilst compression forces such matter from the interstices of the threads, so that at each successive immersion and squeezing, impurities are removed.

A general view of a scouring plant is given in Fig. 14, showing the arrangement of the machines, water and steam connections, also a lecker or soaping machine, conveniently fixed for treating the pieces prior to running them through the scourer.

Fig. 15 is a front view of the rope scourer. The upper part of the framework is removed to show the pieces as they pass

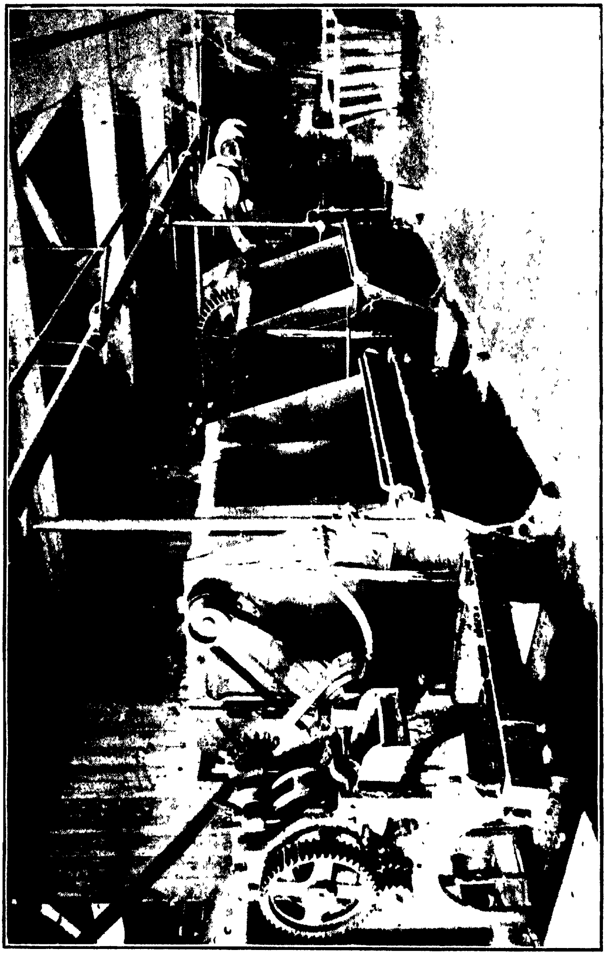


FIG. 14.—View of Scouring Plant.

from the squeezing rollers over the guide roller in front, into the main trough. The driving is also distinctly seen. In some machines, the setting-on motion consists of wheel and screw gearing, as in Fig. 16.

Fig. 13 is an end section of the rope scourer, usually made 5 feet, or 5 feet 6 inches in width. A¹ and B are the squeezing

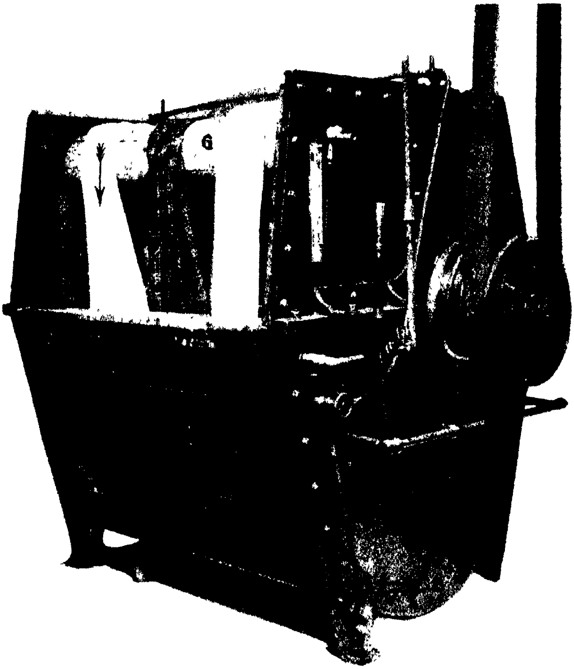


FIG. 15.—Front View of Rope Scourer.

rollers, C and D guide and draw rollers. When rollers A¹ and B are made of wood, they may be 20 inches and 28 inches in diameter respectively. Should either of the main rollers be of metal, the diameters vary, as in Fig. 16. In order to obtain as even a crush as possible upon the pieces, the rollers are sometimes covered with rubber composition; but for ordinary purposes wooden rollers are used of the diameters given. The lower portion of the machine is built into the flooring, making the working parts more accessible, and providing convenient means for running off the waste scour.

Fixed behind A^1 and B is the draft board C, Fig. 13, divided into three sections. Six pieces may be treated at one time, running in pairs through separate apertures in the draft board. Each draft of pieces is placed in the main trough and drawn through board C, over guide G, between rollers A^1 and B^1, and over the front draw roller D, and the beginning and finishing ends sewn together. The scouring solution is in the trough. During the operation, the slide in the upper trough H is open, so that any lye squeezed out of the pieces runs back into the lower trough. The work continues until there are no indications, when the cloth is tested by rubbing the face and under side, of

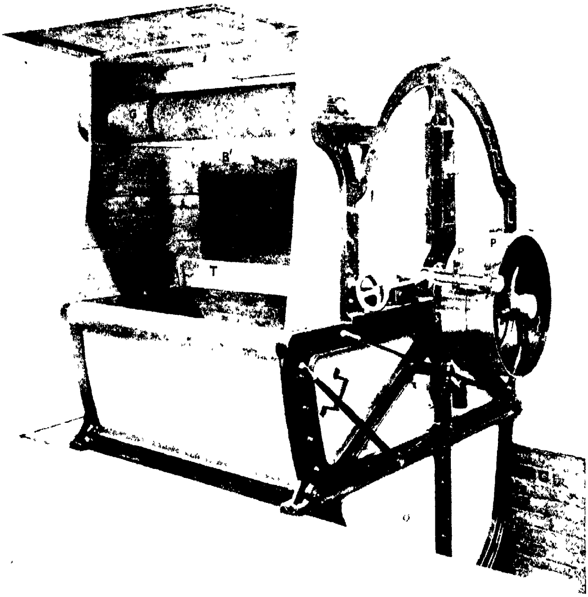


Fig. 16.—Rope Scouring Machine.

the presence of grease. The clean condition is also determined by the bright appearance of the fabric.

(32) *Washing Off.*

This is a rinsing process and takes place in the scouring machine, either after scouring or milling. Warm water flows freely and constantly on to the pieces, as they pass from the draw roller D, into the lower part of the machine, removing all traces of the scour lye. The greasy suds squeezed out of the cloth pass into the upper trough and from thence into the waste pipe. This is effected by closing the valve in trough H and opening the valve in the main trough. A clean-water bath is thus gradually obtained by diluting the suds and removing a quantity of them as the piece passes between the rollers. If the suds were run out of the lower tank and water turned on to the piece, the soapy and dirty sediment in the cloth would not be perfectly washed out. By allowing the pieces to absorb such solution during

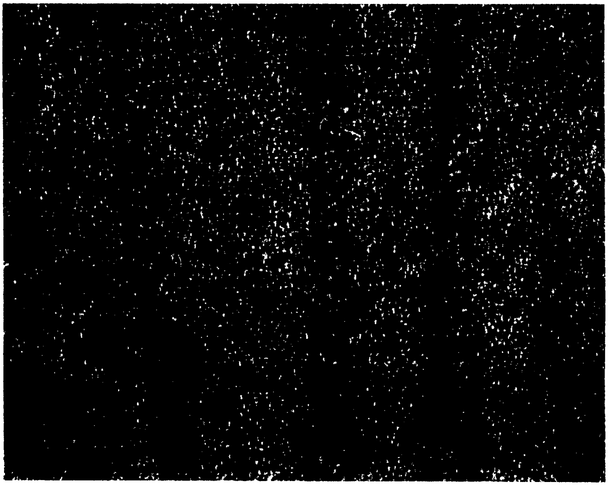


FIG. 17.

the process of changing it to clean water, all the scouring efficiency is retained for extracting the greasy matter. Commencing with the water at 85° F., the temperature is reduced until cold. Should this be effected too quickly, and the time allowed too short, the soap in solution in the piece will not be fully carried off, leaving the cloth comparatively hard. After all traces of the lather have been removed, the final rinsing takes place.

Thorough washing-off is a necessary sequence of good scouring. If imperfectly done it may be the cause of serious defects in the finished fabric. Piece dyes, in which the washing-off and rinsing have not been satisfactory, develop, in dyeing, flaky or blotchy patches due to certain parts being free from the scouring suds and others only partially so, in which case the former take a brighter tone of colour than the latter. Fancy fabrics would suffer in brightness of colour, and possess a blurred dull quality, if any traces of the soap suds remained in the pieces. In heavily milled goods another kind of defect results, namely, inequality of felting property in different parts of the pieces, producing rig marks and streakiness.

(33) *Points in the Use of the Rope Scourer.*

This system of scouring is common in treating heavy greasy fabrics, and the ordinary classes of woollens. In pieces made of low materials it would be impossible, in the open width, to have the repeated squeezings effective enough to expel the dirt and greasy matter from every part of the fabric. Pieces must be scoured through and through, and not merely surface cleansed, and as the greasy compounds impregnate every fibre in the texture, it is only by this mechanical action that some types of fabrics can be perfectly washed. A freer and more efficient scouring of such pieces is possible by treating in the folded state than in the open width.

One difficulty, however, in the use of the rope scourer is the prevention, in certain makes of fabrics, of defects due to the pieces running for a period in the same series of folds. The limited space in which they are held, 8 or 12 inches, in which condition they pass between the squeezing rollers, though 70 or

80 inches wide, is a cause of crease marks. Cuttling in the lower trough does not sufficiently change the relative positions of the layers lengthways of the fabric. The machine minder endeavours to rectify this by opening out the pieces during

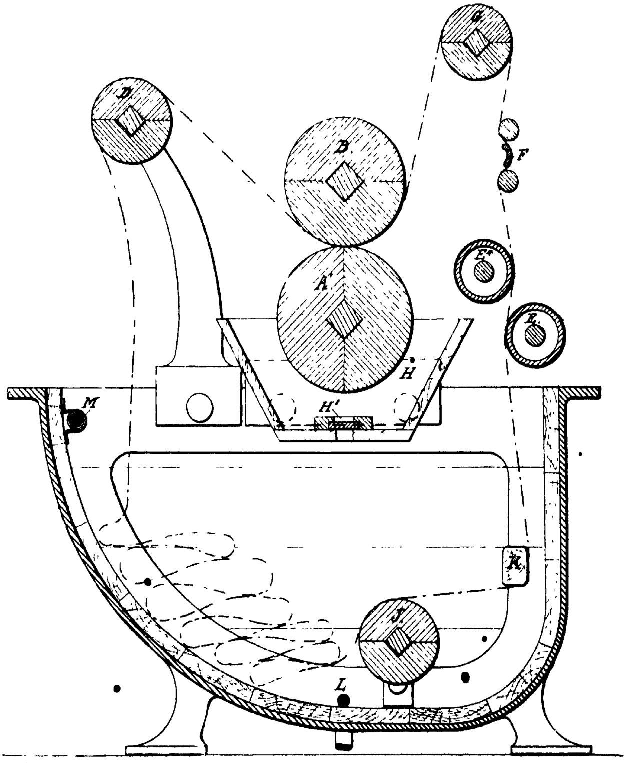


Fig. 18.—Open-width Scourer (section).

scouring, but, at the best, this is an imperfect method of distributing the foldings. Mechanical contrivances have been applied to remedy this defective treatment, such as the use of pairs of smooth rollers inserted in the draft board, or of corrugated rollers, adjustable as to space from each other. The action of either class of roller may minimise this mechanical cause of defects, but a degree of friction which is undesirable necessarily results on the cloth.

Cross drafting is also practised to lessen the effect of operating on the pieces in the folded state. It consists in placing the pieces in the machine in such a way that one series or "draft" will interlace with a second draft in the lower trough, for each passage between the squeezing rollers. This is done by fastening the two drafts of pieces into an endless length, so that they change from side to side of the draft board and the rollers of the

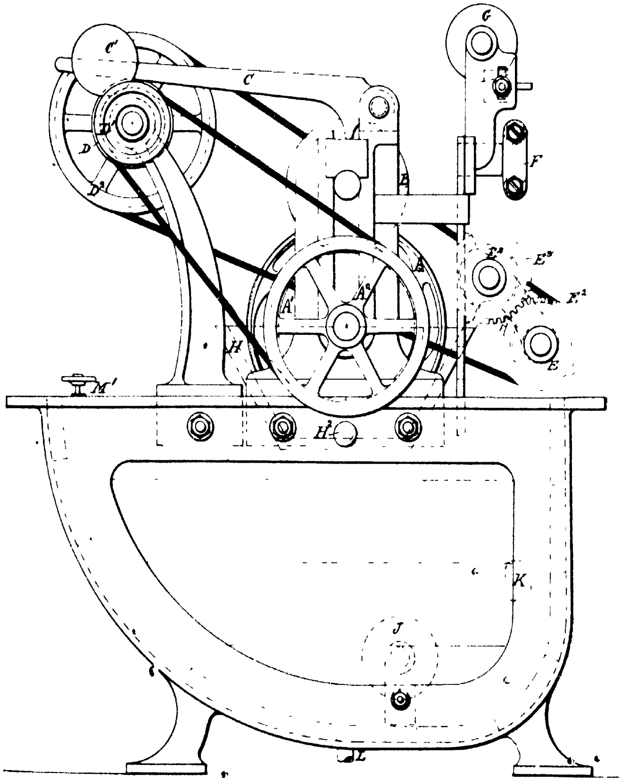


FIG. 19.—Open-width Scourer (side elevation).

machine. Possibly, this is as effective a method of securing frequent and regular changing of the folds in the pieces as can be adopted in this type of scourer.

Rope scouring is, more or less, unsuitable for fabrics composed of materials and yarns in which unevenness of crush tends to develop flakiness, crease marks, and other faults in the woven piece. For example, fabrics made of Crossbred yarns, owing to their wiry, hard and unyielding nature, when scoured by this system rapidly and permanently crease in places, or some threads may, to a slight degree, curl or loop. The stronger the fibre or staple of the wool, the firmer the yarn and more pronounced the faults. Union fabrics, with a cotton warp and mohair or lustre weft, are still less suitable for this system of scouring. Under the squeezing action, the yarns in the folded places in the fabric burst and form loops, so that the pieces are not perfectly level prior to milling, but rather in a condition to rig or crease in the felting process. A specimen of such a fabric is given in Fig. 17. The lines of loops traversing the surface irregularly, are where the piece was folded in scouring. In the milling operation, these formed prematurely or before curliness resulted in other parts of the texture. More increased felting would produce curliness in every part of the fabric, but these sections would be correspondingly pronounced, and the piece still defective.

When the fabrics have a smooth, level, fine surface, as in vicunas and worsteds, it is obviously an essential object in each process of finishing to retain and develop these qualities. If, however, the pieces should be washed and run in folds, the surface is liable to be creased and marked, and any fault produced in textures of this fineness is likely to be accentuated in the subsequent finishing processes.

(34) *The Open Scourer: Construction.*

Figs. 18, 19 and 20 are section and side and back elevations of the open scourer. The method of driving, adjustment and relation of the rollers to each other are the same as in Figs. 15 and 16. In this scourer the scroll opener is applied, consisting of rollers E and E^1, (Fig. 20), for retaining the piece full width during scouring, and in a central position on the roller G, by the action

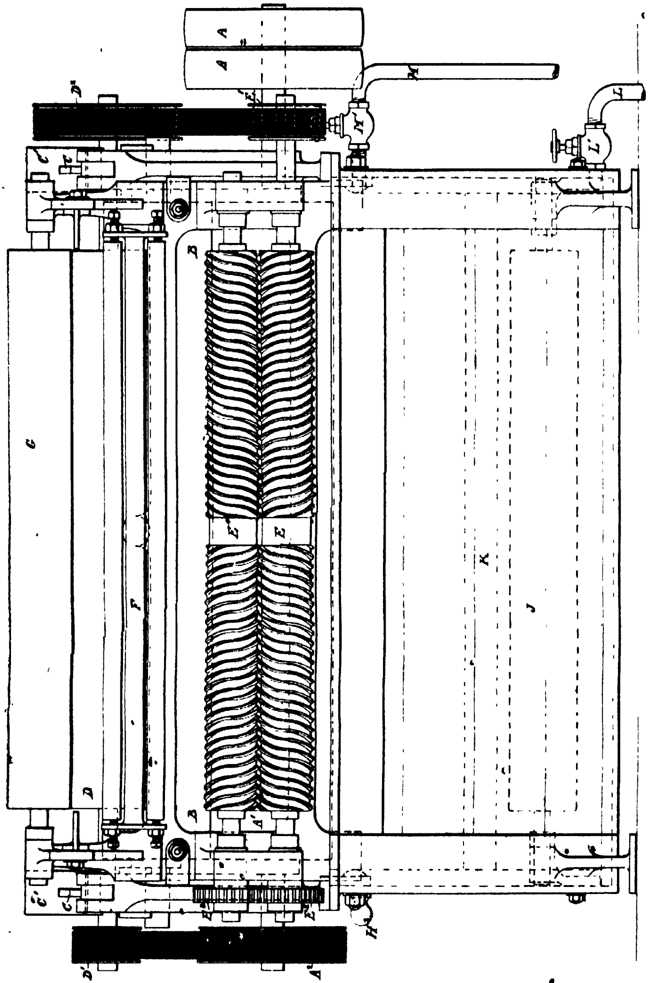


FIG. 20.—Open-width Scourer (back elevation).

of the frame F oscillating on a pivot. The operation of the parts is as follows: A, Fig. 20, is the strap pulley on the main shaft of roller A^1, Fig. 19, which by friction turns B, the amount of pressure of which is regulated by weight C^1 on lever C. On the opposite end of the main shaft is the pulley A^2, which imparts motion to the front draw roller D (with a surface speed similar to the main roller), the shaft of which at the other side carries strap pulley turning the lower scroll roller E. E^2 gears into E^3 on the upper scroll.

The pieces pass between rollers A^1 and B, Fig. 18, and then over roller D and into the trough, over guide J, and round the tension bar K, between the scroll rollers E and E^4, interlacing with the bars of the oscillating frame F, over guide G, and return to the squeezing rollers. The action of the scroll opener is similar to pressing on the cloth from the centre to the outer edges, so that it is constantly maintained straight and level without any actual tension being applied. As the frame F operates on a central pivot, if the cloth tends to move to either end of the roller, this frame rises at the same end and at once causes the piece to assume the normal position on the roller.

(35) *Advantages of the Open Scourer.*

The chief advantage of this machine consists in the pieces being washed full width, and therefore are perfectly even when they pass between the squeezing rollers A^1 and [illegible] Fig. 18, giving a uniform pressure on every portion of the surface of the cloth. There is not the inequality of crush or compression as when the pieces run in folds, and there is an absence [illegible] conditions which develop and make permanent creases. In many classes of goods, especially those made of worsted yarns, the pieces are comparatively clean, so that scouring by this method may be practically as well done as by the older method, with the great advantage that if the pieces are run for a sufficient period, and with proper treatment as to scouring solution, they will be perfectly clean throughout. Every portion of the fabric, whether in scouring or washing-off, is subjected to like treatment; it absorbs the same quantity of scouring solution, undergoes the same pressure at each passage between rollers A^1 and B, and, in washing-off, the water is equally distributed on the cloth. The whole routine tends to secure perfect evenness of result, so essential to uniform dyeing.

The open scourer should be used when cleansing textures made of Crossbred and Botany yarns, and generally those fabrics in which a fine clear surface is required. It may also be used in washing-off heavy felted woollen goods possessing firmness and stiffness of structure, the surface of which is liable to be cracked or damaged in the folds when the process is done in the rope machine.

(36) *Scouring Machine with Flanged Roller.*

The construction of this machine, Fig. 21, in regard to the rollers is similar to an ordinary milling machine, that is to say, the lower squeezing roller is flanged, and the upper roller fits between the flanges and is heavily weighted. The pieces are thus in a more compressed state during the crushing or squeezing than in the rope machine. The other parts of the machine are similar to the rope scourer. T is the upper trough, G the guide roller, B and C additional parts for delivering the piece, after scouring, into the trolley or barrow, and K is the knocking-off board. In addition to the cleansing process between the rollers, there is a spout at the back of the machine which holds about 25 yards of cloth, and gives additional crushing, instead of all the cloth remaining at the bottom of the machine. This method of scouring is chiefly suitable for pieces of a low quality, containing a large percentage of greasy substances, in the manufacture of which mungo and shoddy have been used, and a lubricant of inferior quality. In order to expunge these from the cloth and produce a clean condition, this heavy crushing is essential. By this system, such pieces can be better and more rapidly scoured than in the ordinary rope scourer.

The upper roller is 3 feet in diameter and has a possible pressure of 10 to 12 cwt. on the cloth, producing a thorough crush and a greater degree of softness, which forms a better preparation for milling than is possible by the ordinary machine. The rollers are cog driven, and mounted on springs to secure steadiness of action on the top squeezer.

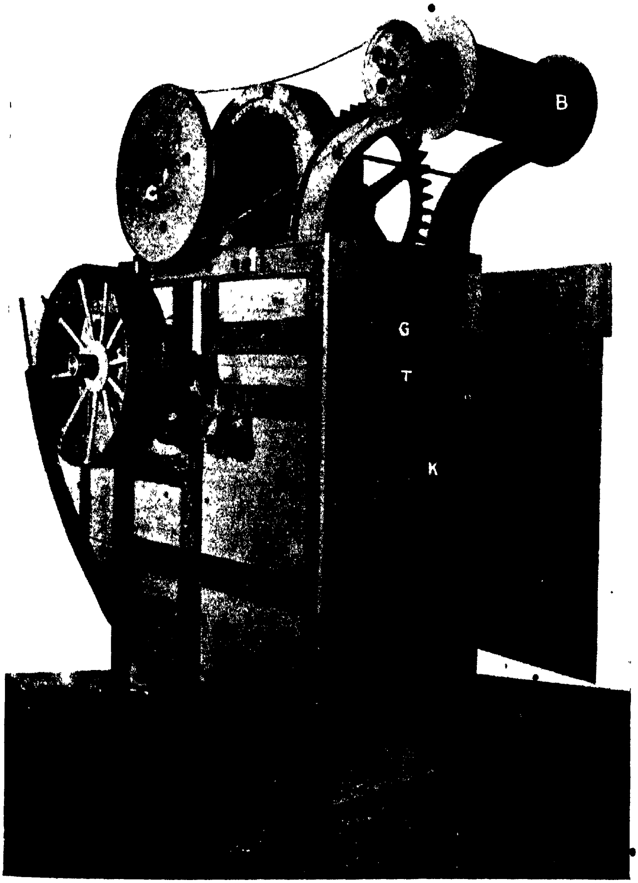


Fig. 21.—Kilburn's Scouring Machine for Heavy Pieces.

(37) *Combined Scouring and Milling Machine.*

This is a combined machine consisting of both scouring and milling parts. As there are many classes of woollen goods in which only a small degree of felting is necessary to impart the requisite compactness of texture, this machine has been constructed with a view of having more economic work without loss of efficiency. It differs from the ordinary scourer in that the squeezing rollers are only 8 inches wide, and that the lower one is flanged, with the two upper rollers fitting between the same. The lower or chief roller is 2 feet and the top rollers 18 inches in diameter, the total width of the machine being 28 inches. It is capable of treating pieces varying in weight from 10 to 180 lb.

The machine consists of lower and upper troughs, and of guide rollers as in Figs. 13 and 18, of the two upper rollers under the control of springs and of the elongated trough or spout in which the pieces are felted warp ways by the spout lid, and weft ways by the spout sides. The latter are connected to levers which are weighted according to the degree of weft shrinkage required. When scouring, only that amount of compression is applied to the rollers to get an effective nip or crush, and there is no weight on either the lid or the sides of the spout, which are hinged. The felting is done by applying weights to the parts mentioned, and running the pieces through soapy solution about 18 inches in depth in the lower trough. Then follows washing-off in the usual way, with the machine adjusted as in scouring.

CHAPTER IV.

THEORY OF FELTING.

(38) Qualities of Wool in Relation to Felting. (39) Shrinkage Properties of Merino and Cheviot Wools. (40) Felting Contrasts. Merino and Southdown Wools. (41) Utility in Woven Manufactures of Wools of Different Shrinking Qualities. (42) Yarn Structure. (43) Felting affected by Yarn Composition. (44) Methods of Yarn Construction and Felting. (45) Shrinkage of Fabrics made of Re-manufactured Fibres. (46) Degree of Twine in the Yarn. (47) Folded Yarns and Shrinkage.

(38) *Qualities of Wool in Relation to Felting.*

THE felting or shrinkage property of a woven fabric is determined by the nature of the wool fibre; the structure of the yarns; and the construction or make of the cloth. Each of these characteristics has an important influence upon the degree of felting possible in woven productions; and also exercises a modifying effect upon the actual process of felting or milling.

In regard to wool, its felting power is controlled by:—

(1) The physical structure of the fibre.

(2) The elasticity, waviness and density of the staple.

(3) Uniformity of length of fibres in the locks of wool, and the strength of the staple.

To make this clear, Merino (Tasmanian) and British (Cheviot) wools may be contrasted in these qualities, Figs. 22 and 23.

Comparing, first, the physical structure or the external formation of the fibres of the two wools, it will be observed that the Merino is much finer and truer in growth than the Cheviot, with a larger number of serrations in a given length of fibre; and these, as is well understood, are active elements in the milling of the cloth.

Second, the Merino (Fig. 22) is elastic, wavy and dense in staple; but the Cheviot (Fig. 23) comparatively open, and consisting, on the average, of a less number of fibres. In waviness, the difference is also marked, Merino lambs' wool—possessing excellent felting property—being distinguishable for this quality; whereas English wools, even of the short staple class, such as the Downs (Fig. 24), are wanting in waviness, and also felting power.

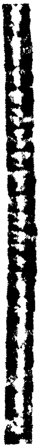


Fig. 22.
Fine Merino (Sydney).

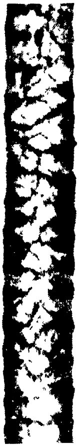


Fig. 23.
Border Cheviot.

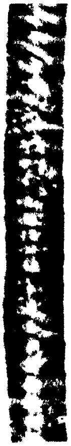


Fig. 24.
Southdown.

Third, strength and soundness of staple and uniformity of length of fibre induce and maintain felting; a wool tender in staple may felt, but not for a like period, or to the same degree, as one possessing these qualities. The high breaking strain of individual filaments, which is found in the better grown qualities of medium and coarse stapled wools (Figs. 23 and 26), also affects the duration to which shrinkage may be continued. This is contingent upon the average fibres in the lock being of a similar quality, length and diameter. In some of the finer Cheviots, the felting power has been proved to be more active in the third and fourth hours in the milling machine than during the first 120 minutes. Want of waviness and density of serrated surface were here neutralised by the soundness and strength of the fibres in the wool staple.

(39) *Shrinkage Properties of Merino and Cheviot Wools.*

The results of two series of experiments may be useful. The first series contrasts the relative shrinkage of Merino and Cheviot wools under like conditions when used as weft in a union texture; and the second series contrasts the felting qualities of Tasmanian Merino and Southdown wools in the following relations:—

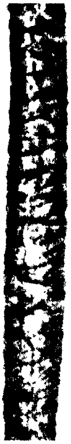


FIG. 25.
Welsh.

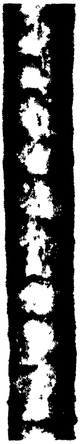


FIG. 26.
Lincoln.

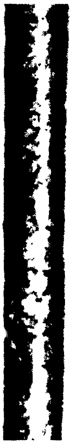


FIG. 27.
Mohair.

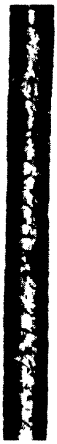


FIG. 28.
Alpaca.

(*a*) Merino warp and Merino weft. (Yarn of the Saxony type.)

(*b*) Merino warp and Southdown weft.

(*c*) Southdown warp and Southdown weft. (Yarn of the Cheviot type.)

(*d*) Southdown warp and Merino weft.

Considering the first series, the counts of the weft yarn, both Merino (Fig. 22) and Cheviot wools (Fig. 23) were 20 skeins, with approximately twelve turns per inch, the warp being cotton, set 31 inches in the loom, and in 12's reed 2's. The yarn structure was, as near as practicable, the same in each quality of wool, thus eliminating any cause of difference in the felting other than the physical properties of the raw material.

Fig. 29 shows the relative widths of the fabric from the Plain weave, Prunelle twill, $_3{-}^1$, and $_2{-}^2$ twills, and backed $_3\ ^1$ Swansdown, after scouring, milling, and finishing, in the order in which they were woven, Cheviot and Merino weft alternately. The picks per inch were in the Plain weave, 40; in the Prunelle, 50; in the $_3{-}^1$ twill, 55; in the $_2\ ^2$ twill, 57; and in the backed $_3{-}^1$ Swansdown, 80. The different shrinkages of the two yarns is clearly defined in these fabrics.

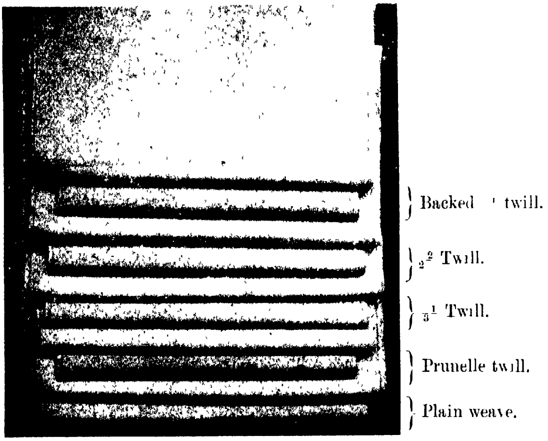


FIG. 29.

Fig. 30 is a diagram of the contraction or shrinkage curves of the two wools, under corresponding periods of time and treatment, in the scouring and milling processes. That the structure of the fibre is the chief modifying element in the changes effected, is apparent when the curves 1 to 5 are compared. There is a similar ratio of alteration in the textures made of

Merino and Cheviot yarns in each pair of curves. Relatively, the two fabrics undergo the same shrinkage in the plain, twill and other weaves. Neither the yarn nor the fabric structure are, therefore, recognisable factors in any difference in the measure of contraction here indicated, when each set of curves is considered, and the effect of the Merino weft is compared with that of the Cheviot. The influence of the weave is traceable in the variations in shrinkage in Plans 1 to 5 in both materials.

The investigation is thus restricted to the comparative milling properties of the wools of which the yarns are composed. It is interesting to note, in the first place, that the nature of each material has a different power of contraction prior to, and during scouring. Taking the shrinkages on the reed and scouring lines A and B, they are as follows:—

TABLE III.

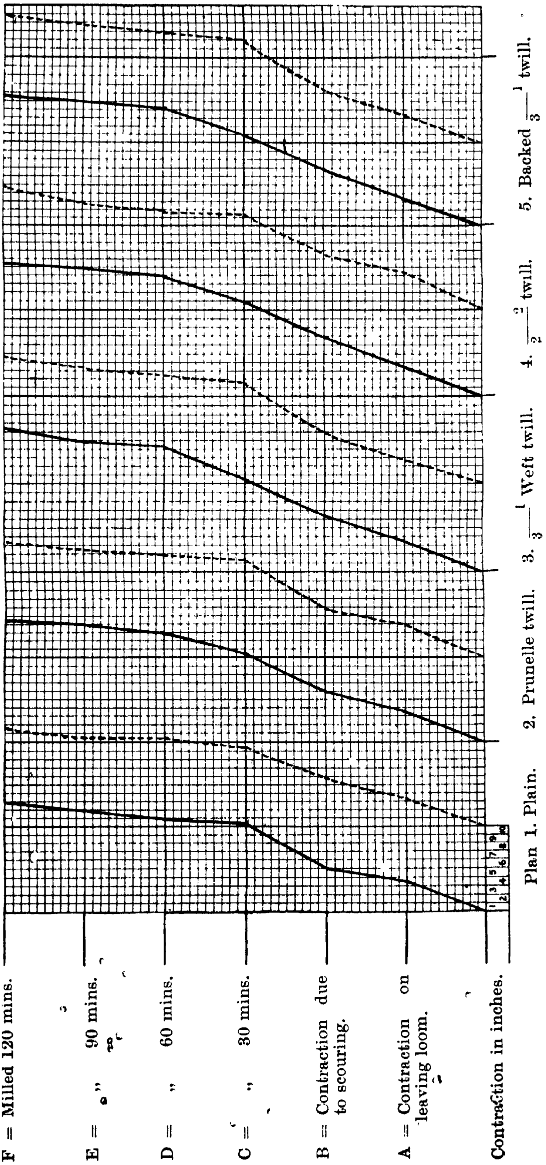
SHRINKAGE OF MERINO AND CHEVIOT FABRICS.

Plans.	Plain Weave.		Angled Prunelle.		Swansdown.		$\frac{2}{2}$ Twill.		Backed Swansdown.	
Wool.	Merino.	Cheviot.	Merino.	Cheviot.	Merino.	Cheviot.	Merino.	Cheviot.	Merino.	Cheviot.
Contraction in Inches:—	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
Line A . .	3½	2½	3½	2½	3½	2	3½	3	3½	2¼
Line B . .	5	4¼	6	5	6¼	5	7	5	7	5

The Merino weft shows, at this stage, higher shrinkage than the Cheviot. On the scouring line B, the superior felting property of the Merino is also apparent.

The behaviour of these wools in this process coincides with what occurs in the several periods of milling. The fine Merino felts more rapidly, and to a greater degree than the Cheviot, as is observable by following the variations in the curves on lines C and D. They more closely approximate each other in the two latter periods E and F.

COTTON WARP AND MERINO (SAXONY) WEFT.



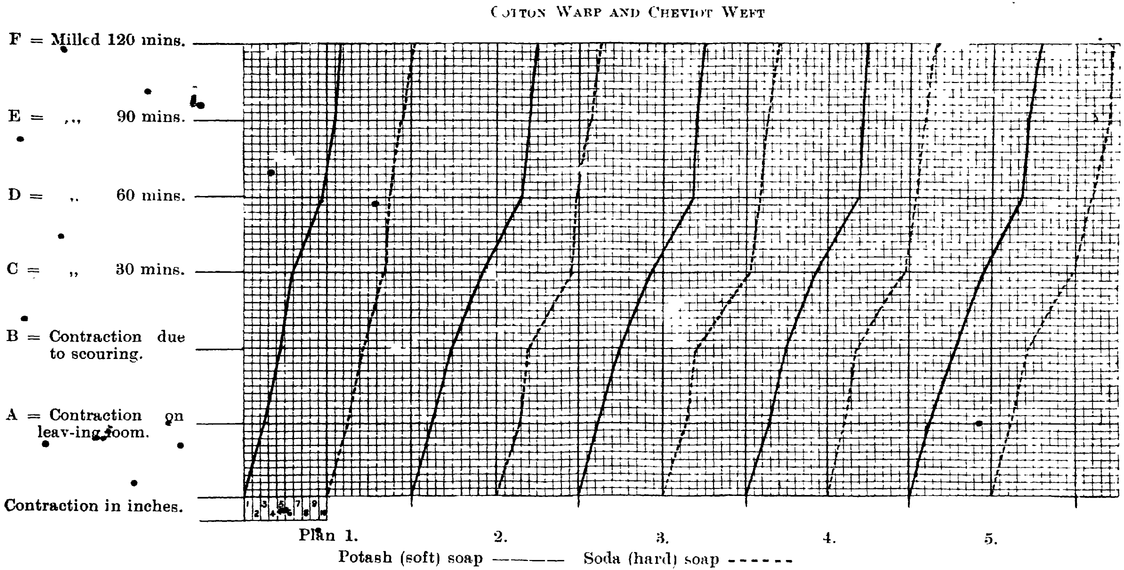


FIG. 30.—MILLING COMPARISONS IN SAXONY AND CHEVIOT FABRICS AND POTASH AND SODA SOAPS.

Milling research has confirmed this theory, but the ratio of shrinkage under various conditions as to time, pressure and temperature still leaves many problems unsolved.

The shrinkage curves on lines C to F prove (1) that when the felting quality of these wools is measured, it is variable in definite periods of time; and (2) that the excessive felting of the Merino appears in the first, and is maintained to the last period. That such wools are relatively of dissimilar felting property, trade practices and general observation have determined, but their characteristic behaviour in the several periods of milling — which form so valuable a feature in manufacturing—are only definitely determinable by experimental research.

(40) *Felting Contrasts: Merino and Southdown Wools.*

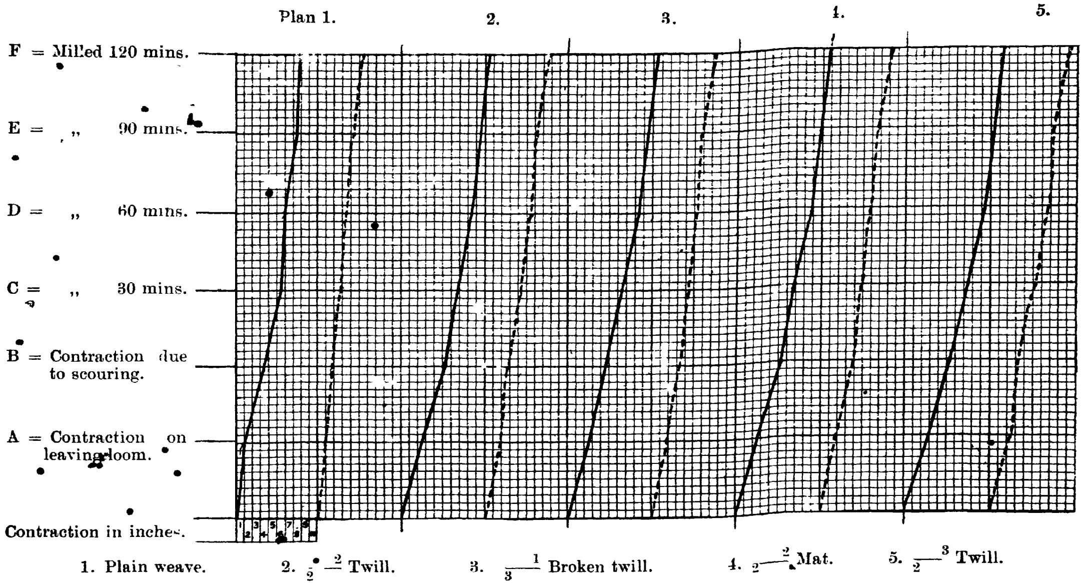
The effect of Merino wool in fabrics composed of Southdown warp (Crossbred or Cheviot quality) and Merino (Tasmanian) weft, or *vice versa*, in the process of felting, and also the contrasts between the felting property of these wools in other technical conditions than those already described, are indicated in the analyses of the milling results of fabrics made as follows, and woven together:—

Warp 1.	Warp 2.
20 skns. (Tasmanian wool.) 13·2 turns per inch.	20 skns. (Southdown wool.) 13·4 turns per inch.

Wefts: Same as warps.

Weaves:		
	Plain,	24 picks per inch.
	$\frac{2}{2}$ twill,	36 ,, ,, ,,
	Swansdown,	36 ,, ,, ,,
	Mat,	32 ,, ,, ,,
	$\frac{3}{2}$ twill,	38 ,, ,, ,,

In order that the felting should be dependent upon the physical properties and qualities of the two wools, and not upon technicalities in manufacturing, the yarns used were, as



Merino ——— Southdown ------

FIG. 31.—MILLING COMPARISONS IN MERINO AND SOUTHDOWN FABRICS.

in the first series of experiments (Par. 39), of similar counts and turns per inch.

The shrinkage curves of the pure Merino and Southdown are given in Fig. 31. In each instance, it will be noticed that the Southdown is more uniform than the Merino. Taking the curve on the plain weave, it traverses the same unit for each period up to ninety minutes after scouring, and only makes a variation of half a unit in the last period, or between lines E and F. Between lines B and C, C and D, and D and E, it is the same. That of the Merino, between lines A and C, moves 5½ units, and the Southdown 2½, but between C and D, the two wools have a similar shrinkage and also between E and F, but the Merino curves comprise two units between D and E, against one in the Southdown. In the twill, the curves have a corresponding relation, from A to D, namely, six in the Merino and four in the Southdown, then in an almost parallel relationship to line F. The curves for the weaves, swansdown, mat and $_{2}\text{—}^{3}$ twill, have, relatively, similar units of difference to those of the plain and $_{2}\text{—}^{2}$ twill.

The cause of the increase in shrinkage, due to a change in the weave, will be fully treated of later, but here it is a question of the ratio being maintained in the fabrics made of both Merino and Southdown wools. As the shrinkage of the former increases, so proportionately does the latter. If this did not follow, it might be assumed that there was some auxiliary factor in operation, but the change being constant in each wool clearly determines that the quality and structure of the fibres of the respective materials are alone responsible for the different results, in each weave, which arise in scouring and milling.

It has yet to be explained how the behaviour of these wools in regard to shrinkage is affected when the Merino warp is woven with the Southdown weft, and the Southdown warp with the Merino weft; that is (1) to what degree one wool may modify the properties of the other when thus used; (2) to what degree the Merino controls the felting; and (3) to what degree the finer and softer wool, with the fibres of a lesser breaking strain, exercises a greater felting quality than the wool with the thicker and stronger fibres. The following contraction results bear upon these problems:—

TABLE IV.

SHRINKAGE IN SCOURING AND MILLING OF MERINO AND SOUTHDOWN WOOL FABRICS.

Weave.	Weft.	Percentage of Contraction in Scouring.		Percentage of Contraction in Milling. Period: 2 hours.	
		Merino Warp	Southdown Warp.	Merino Warp.*	Southdown Warp.**
Plain, A .	Merino	10·25	11·75	23·50	25·75
$\frac{2}{2}$ twill, B .	,,	16·75	17·50	31·00	32·25
Swansdown, C	,,	13·25	16·75	31·00	32·25
Mat, D . .	,,	16·00	16·00	32·25	34·50
$\frac{3}{2}$ twill, E .	,,	16·00	18·75	33·75	36·75
Plain, A′. .	Southdown	5·75	5·75	18·00	16·75
$\frac{2}{2}$ twill, B′ .	,,	8·75	8·75	26·50	23·50
Swansdown, C′	,,	8·75	10·25	23·50	22·00
Mat, D′ . .	,,	10·25	11·75	25·00	25·00
$\frac{3}{2}$ twill, E′ .	,,	10·25	10·25	26·50	29·25

*A to E. *Effect of two hours' milling on fabrics made of Merino warp and weft.*
**A to E. ,, ,, ,, *Southdown warp and Merino weft.*
*A′ to E′. ,, ,, ,, *Merino warp and Southdown weft.*
**A′ to E′. ,, ,, ,, *Southdown warp and weft.*

An analysis of this Table shows that, first, the Merino weft increases the felting property of the Southdown warp, giving in the plain weave A, a plus shrinkage of 9 per cent. over A′; in the twill B, of 8·75 per cent. over B′; and in the swansdown C, of 10·25 per cent. over C′. Second, that in these experiments, the Merino weft, in the period named, also produces a plus shrinkage on the Southdown warp as compared with the Merino warp. The explanation of this is found in the shrinkage curves, Fig. 31, where from line E to line F the Southdown has a higher shrinkage quality than the Merino. This is distinctly seen in Weaves 3, 4 and 5. In the swansdown and mat weaves, the Southdown moves 1½ units to the Merino 1 unit; but in the

$_{2}{-}^{3}$ twill, 2½ units in the former to 1 in the latter, so that here the Southdown accelerates the shrinkage of the Merino. Third, the Southdown weft diminishes the shrinkage of the Merino warp in both the scouring and milling processes. Compare again the plain weave A, Merino warp and weft, shrinking 10·25 per cent. with the same weave A′, in Merino warp and Southdown weft, shrinking 5·75, or in milling 23·5 in the former and 18·0 in the latter; and similarly with other weaves.

These comparisons are confined to contraction in the width of the fabric, and show both in scouring and felting that whereas the Merino weft increases the felting on the Southdown warp, the Southdown weft lessens the shrinkage on the Merino warp.

(41) *Utility in Woven Manufactures of Wools of Different Shrinking Qualities.*

The fact that Crossbred and Merino wools behave differently in the milling process, both as regards periods and degrees of felting, has led to the manufacture of special fabrics in which this property produces the characteristic effect required. It follows that, when separate yarns are made from these two wools, and woven alternately either in warp or weft, during the period when the Merino or Saxony yarn has the higher felting power, the Southdown must contract. Felting is the gradual interlocking of fibres, as distinct from yarn contraction, without fibrous homogeneity being produced. In illustration of the compound process referred to, take the felting of the rug specimen (Fig. 32) woven one pick Saxony and one pick of Crossbred yarn. As described, in the early stages of felting the Merino wool has the power to cause the yarn of the Cheviot, or similar wool, to be drawn into loops or buckles. The foundation of the texture becomes a mass of intermatted filaments, on the surface of which are distributed loops or buckles of the yarn of less shrinking power, and the continued milling of other fibres in the fabric does not eradicate this characteristic.

Other applications of the distinctive felting effect of Merino and Crossbred wools and Mohair obtain in dress and mantle textures and trimmings. Imitation astrakhans (Fig. 33), in which the curl is due to milling, are examples, on account of the method of construction and the use of cotton for warp, and fine Saxony and semi-lustrous, or lustrous yarns for weft. There is, in the Saxony, a material of sound felting property; in the cotton, a

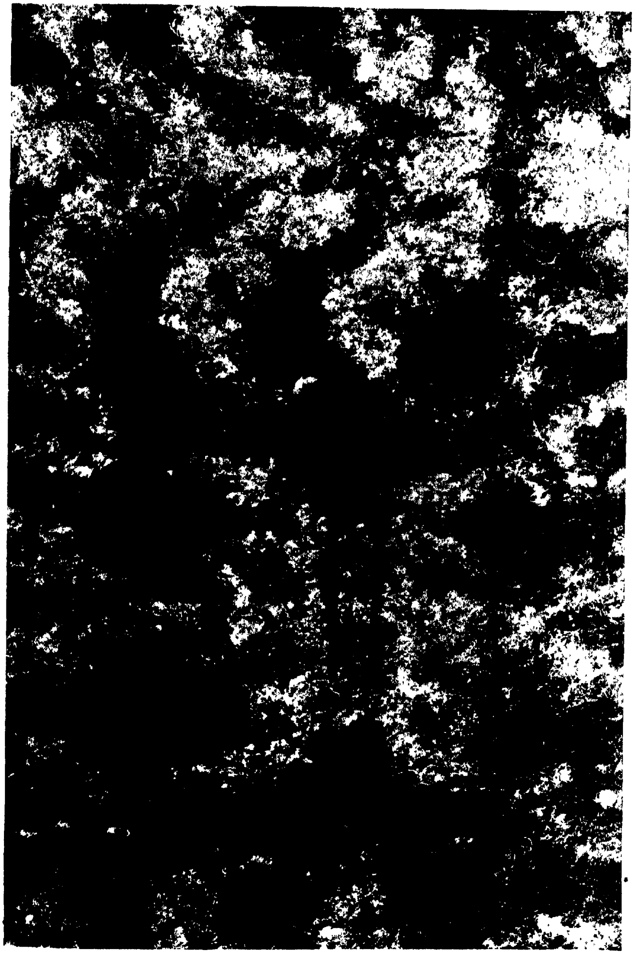


FIG. 32.—Union Fabric, showing the effect of milling on Merino and Crossbred yarns, woven pick and pick.

fibre unshrinkable by the methods applied; and on the face, a lustrous yarn of totally distinct fulling power to the Saxony. The fabric is built to have a plain cotton centre with a sateen woollen underside, and floats of lustre yarn on the face. The structure is thus arranged to emphasise the varying milling properties of the yarns. From the deductions made it is evident, as the ratio of felting is diminished in the face yarn and increased in the Saxony, by reason of the weave construction there ensues, in the preliminary period of milling, a fabric with the underside consisting of felted yarn and the upper surface of curls. These loops or curls may be diversified in character and dimensions by the structure of the weave and the nature of the yarn, that is, its lustrous quality and counts. Thus, in the same fabric, by appropriating a wool of the fine Merino class to the underside,

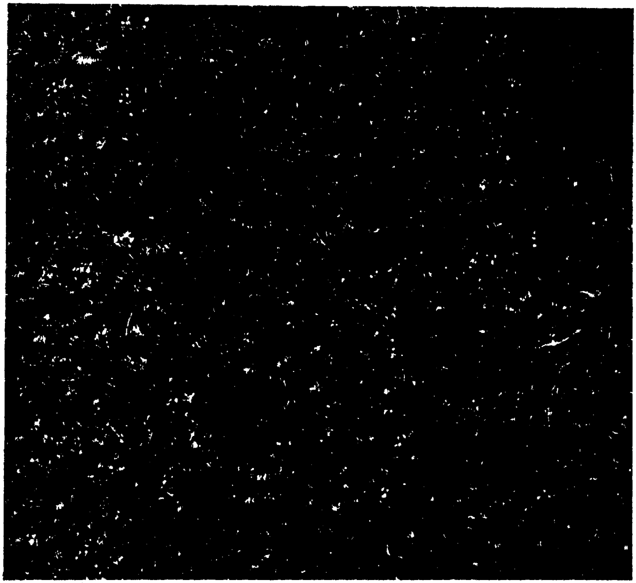


FIG. 33.—Curl Fabric: Effect of milling.

and one of a Crossbred nature to the face, the former is made to yield a smooth surface, but the latter is covered with small curls of a similar character to those obtained by using wires. Yet in the loom both sides of the fabric are level and even, and there are no traces of this distinctive characteristic which develops in felting.

(42) *Yarn Structure.*

Considering the different methods of converting wool into yarn, sufficient regard, in explaining the theory of felting, has not yet been given to this subject. Next to the structure of the wool fibre is the yarn structure as a modifying element in the felting of woollen, worsted and union fabrics. It may induce and accelerate, or diminish and retard the natural felting of the material.

Yarns vary in felting property according to (1) quality and nature of the material; (2) method of construction, woollen or worsted; (3) degree of twine inserted in spinning or twisting; and (4) whether single or folded, that is, consisting of one or several threads folded or twisted together.

(43) *Felting affected by Yarn Composition.*

As the nature of the yarn is so definitely related to the milling property of the fabric, the materials of which it is composed—modifying its strength, evenness, elasticity and density—form an initial cause of the felting property possessed by the woven fabric in which such yarn is used. Wools may have a similar serrated structure, but differ in quality, staple, and the average diameter and length of the fibre. The character of the yarn is determined more by these features of the wool than by its structural formation. All physical peculiarities of the fibres are noticeable in the quality of the yarn. For example, considerable variation in length of fibre results in a yarn wanting in uniform breaking strain, or variation in the diameter of the fibres results in a yarn irregular in density and thickness. These characteristics in wool closely affect the structure of the yarn and in consequence the felting process.

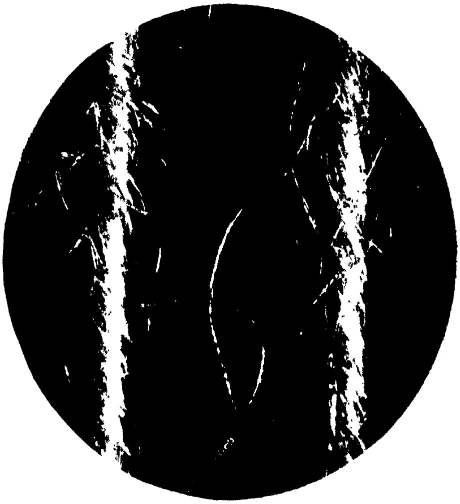


FIG. 34.—Cheviot yarns. 12 skeins (13·8 turns per inch).

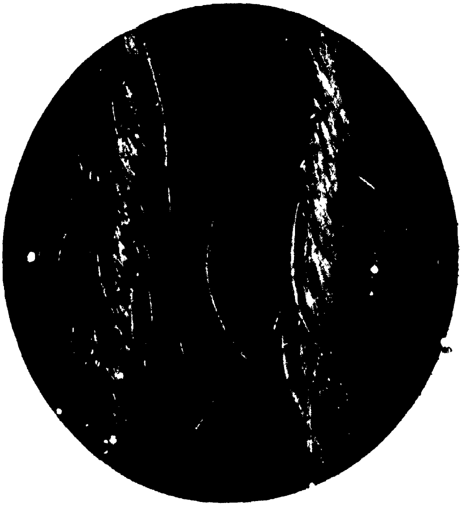


FIG. 34A.—Cheviot yarns. 12 skeins (8·3 turns per inch).

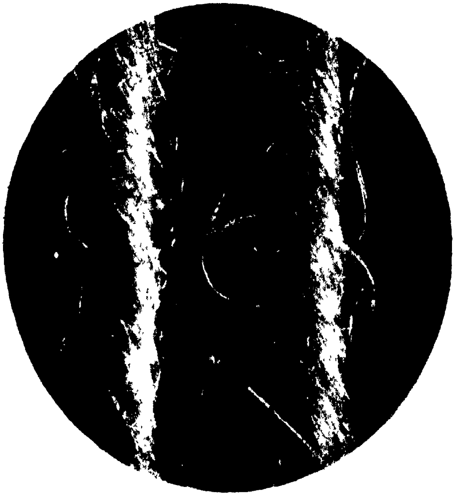


FIG. 35.—Welsh-wool yarns. 12 skeins (11·8 turns per inch).

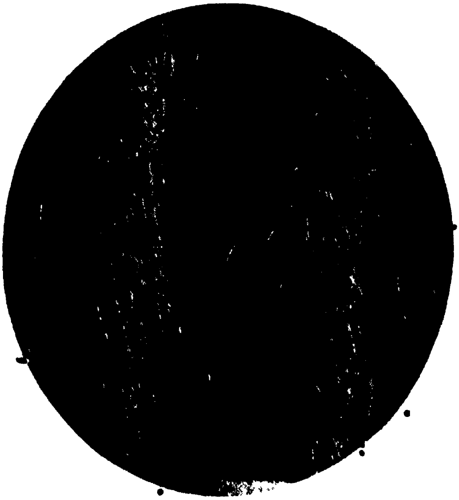


FIG. 35A.—Welsh-wool yarns. 12 skeins (6·5 turns per inch)

This will be better understood if yarns made of Border Cheviot and Welsh wools, and Yorkshire Crossbred and Saxony wools are compared, and also contrasted in felting property. Figs. 34 and 34A are threads spun from Cheviot, Figs. 35 and 35A, from Welsh wools to corresponding counts. The true qualities of a rough Cheviot yarn are peculiar to the threads in Figs. 34 and 34A. There is a fringe of straggling fibres, rolled into clusters, with the mass of the fibres twirled in one progressive movement. Variation in length and diameter of fibres causes, in spinning, the thicker and longer fibres to force the finer into the core of the yarn.

From the micro-photographs of the fibres of the Cheviot and Welsh wools (Figs. 23 and 25) it will be seen that the Welsh are smaller in diameter than the Cheviot. This is also traceable in the yarns (Figs. 34 and 35). There is a larger percentage of fibre in the Welsh than in the Cheviot yarns, though both are spun, as seen, to the same counts.

Experiments in fabrics of like setting with these two yarns proved the Welsh to be somewhat superior in felting to the Cheviot. The latter shrunk more unevenly, and developed a blanket-like handle and character. This was caused by the fine fibres felting more readily than those of a coarser nature, and forming a texture to which the latter were, by continued treatment in the milling machine, matted rather than felted. With the Welsh yarn the process was different. The fibres being of a higher average fineness, the milling was more equalised, so that a greater percentage of the wool felted at one period, with less of the blanket quality in the fabric. If a finer-fibred Cheviot wool had been used, its felling power would have been at least equivalent to that of the Welsh.

Fibrous density is a valuable felting quality. Yarns composed of coarse-fibred material are, comparatively, lacking in felting efficiency. In this consists one of the chief disagreements between Saxony and Crossbred, or Merino and Cheviot yarns. Saxony owes its higher shrinking power, in the first place, to a fuller serrated fibre, but there is also fineness in its favour in the yarn, and this fixes the number of fibres in a given diameter of thread by mechanical means which are amenable to no laws of variation. It is clear, therefore, that two yarns of the same counts, but one consisting of a higher percentage of fibres than the other, must differ in felting power. But when it is considered that the yarn with the higher percentage of fibre is also composed of wool of the more serrated structure, the superior felting power of a Merino as compared with a Crossbred yarn is increasingly apparent. Figs. 36 and 36A, and Figs. 37 and 37A show how such yarns differ from each other in these fibrous properties. They are of similar counts and twine, but Fig. 36 made from Tasmanian wool, and Fig. 37 from Yorkshire Crossbred. The difference between the structure of the two threads is greater than between the Border Cheviot and the Welsh, as might be expected from the use, respectively, of a fine (Tasmanian) and a comparatively coarse-fibred (Yorkshire) wool. Contrasting the two, it will be seen that the Tasmanian is almost

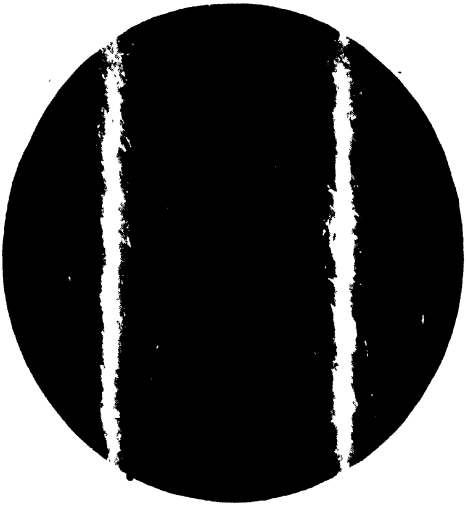


Fig. 36.—Saxony. 20 skeins (Hard Spun).

a solid mass of fibre with a certain amount of extraneous filament, but lacking the comparatively "wild" character possessed by the yarn made of Yorkshire wool. The greater density of the thread in Fig. 36 is another factor that imparts felting power to the fabric in which it is used.

From these examples, it will be clearly understood how the nature of the yarn varies in felting strength with the difference in the fineness, length and evenness of the fibres in the wool, in addition to its physical structure. Yarns may be made precisely in the same way, but when there is such a dissimilarity in these qualities of the materials as in the threads which have been compared, there naturally follows a difference in the shrinkage properties of the fabrics into which they are manufactured.

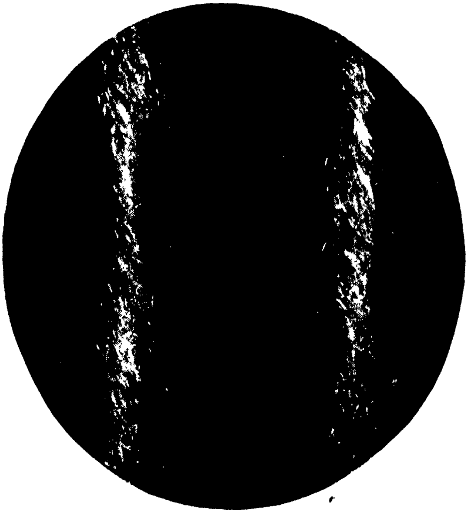


FIG. 36A.—Saxony. 20 skeins (Soft Spun).

(44) *Methods of Yarn Construction and Felting.*

In the spun yarn, there are fibrous conditions which are conducive to, and others detrimental to, sound felting. A number of fibres laid in parallel form, straight and level in the thread, are not in the most suitable relation for felting. On the other hand a cluster of fibres, crossing and intertwining with each other, curly and wavy, are favourable to intermatting, and to becoming, under compression, increasingly meshed. The former condition is illustrative of the typical or true worsted, and the latter of the true woollen yarn. Several varieties of thread are spun between these two extremes. Experiment and research prove that the woollen has the higher felting property, so that the more closely the worsted structure is approached the less the felting quality of the fabric. Whatever method of yarn structure is adopted, the natural felting property of the fibre is not diminished; but, rather in the woollen or carded thread, the fibres are induced to felt, whereas this quality is not assisted, to the same degree, when the fibres are in the relation formed by the processes of combing and gilling.

There are, therefore, three essential features in which yarns made on these principles differ from each other. First, the woollen thread contains a much larger percentage of fibre, counts for counts, than the worsted; second, it possesses a more undulated surface; and third, it has more free ends of fibres, which afford the least resistance in felting.

These qualities of the two yarns may be contrasted in Figs. 38 and 38A, and 39 and 39A, the former being made on the woollen principle, and the latter on the worsted, but both spun to similar counts from the same kind of wool. The straightness of the fibres and evenness of the surface in the worsted, and the comparative irregularity of the woollen are clearly defined. In the twofold threads from the same wools, Figs. 40 and 41, these characteristics are still more accentuated. The worsted retains its straightness of structure, with the bulk of the fibres level or in a line, whilst the roughness of surface and the meshes of fibres obtain in the woollen in a more marked degree. Such strongly developed points of difference in yarn structure have an important bearing upon the felting property of fabrics. In a thread like Fig. 41, from which much of the short filament has been removed, and the curliness combed out of the fibres, there cannot be that disposition to mill as in the woollen, in which the fibres largely possess their natural qualities, and, as indicated, are carded and twisted in a manner that leaves them crossing each other in a more diversified way.

In experiments made with the yarns in Figs. 38 and 39, the yarn constructed on the woollen system made a fabric better adapted for milling than that on the worsted system. In instances where a fine Merino wool was spun to the same counts by carding, and spinning on the self-actor, to a similar yarn made on the worsted method, and also woven into a fabric of the same structure, the woollen had the higher felting property. As an example of this, reference may be made to experiments in which a 3's worsted, and a 7 skeins woollen (both of similar diameter), were used. In the milling of both fabrics together, the texture made of the woollen yarn shrank fully 8 per cent. more than the worsted. Here, the excess of shrinkage on the woollen was chiefly due to yarn structure.

(45) *Shrinkage of Fabrics made of Re-manufactured Fibres.*

Mungo, shoddy and other wool substitutes have not the same shrinking power as the raw materials from which they have been obtained. The process of grinding, or garnetting in the case of waste material, reduces the felting property of the fibre. Taking yarns made of Tasmanian wool, and of material reduced from waste from a similar quality of wool, and producing fabrics of the same setting in plain, twill and broken swansdown, the shrinkages were as follows:—

TABLE V.

Comparison in the Shrinkage of Fabrics made of Tasmanian Wool and Pulled Waste.

	Percentage of Contraction in Fabrics made of Tasmanian Wool			Percentage of Contraction in Fabrics made of Pulled Waste.		
	Milling Periods.			Milling Periods.		
Weave.	30 Minutes.	60 Minutes.	90 Minutes.	30 Minutes	60 Minutes.	90 Minutes.
Plain . .	23·50	31·75	41·75	12·50	22·25	33·25
$\frac{2}{2}$ twill. .	29·00	33·25	44·25	22·25	31·75	41·75
Swansdown .	30·55	39·00	47·25	20·75	33·25	40·25

The higher felting property is seen in each period in the yarn made of pure wool, but the ratio of shrinkage in each successive period is similar in both materials. This is an indication that the quality of the fibre of the pulled waste was, originally, of a similar fineness as that of the Tasmanian wool.

As the pulled waste is reduced in quality, according to the material from which it is obtained, the difference between the shrinkage of the cloth and that made from pure wool is proportionately increased.

Another feature which is exemplified by these results is the shrinkage life of pure wool as compared with mungo, or other re-manufactured fibre; that of the wool continues for a much longer period owing to the length and elasticity of the fibre. At a period when a fabric made from wool would be steadily shrinking, that made from waste would have lost its felting power, and instead of the cloth continuing to shrink in length and width the work in the milling machine would have the reverse effect.

(46) *Degree of Twine in the Yarn.*

The practice in manufacturing is to use a soft spun yarn for weft in fabrics which require to be well milled, and in which the warp yarn is twofold, or hard in twine. The primary object of this is to facilitate contraction of the cloth in the process

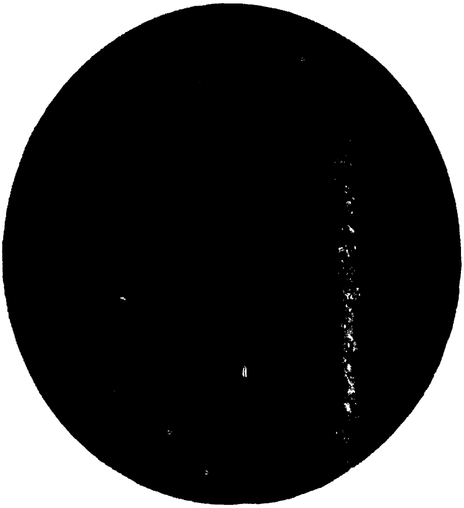


FIG. 37.—Crossbred. 20 skeins (Hard Spun).

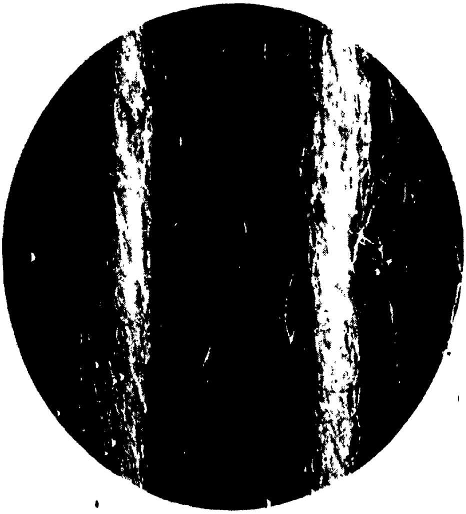


FIG. 37A.—Crossbred. 20 skeins (Soft Spun).

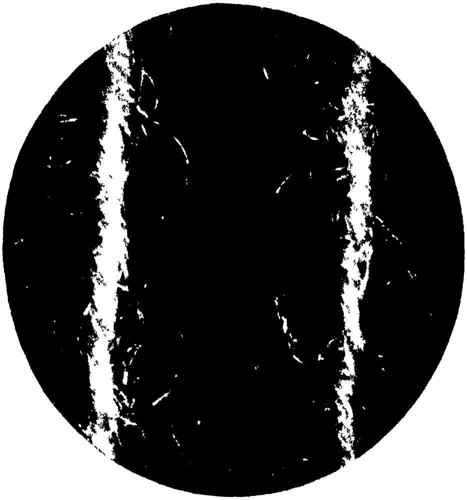


FIG. 38.—18 skeins Woollen Yarn (Southdown Wool), 16 turns per inch.

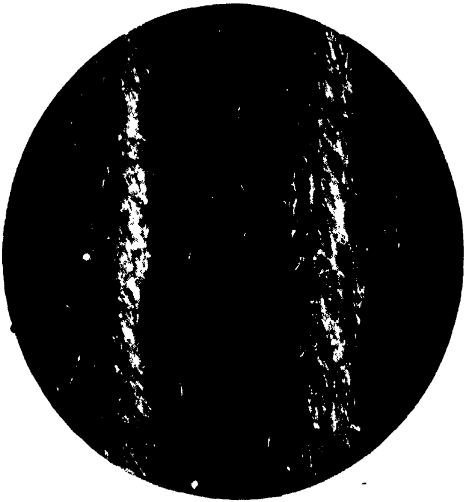


FIG. 38A.—18 skeins Woollen Yarn (Southdown Wool), 11·4 turns per inch.

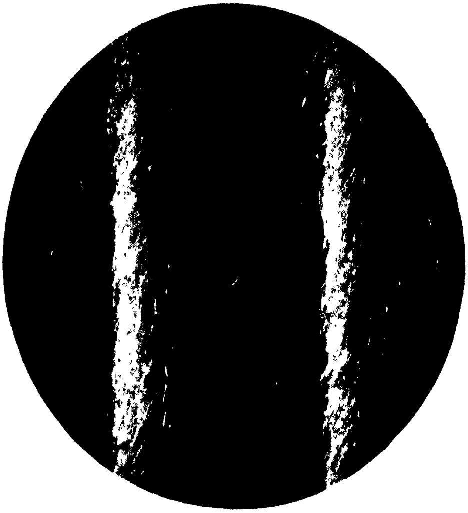


Fig. 39.—8's Worsted Yarn (Southdown Wool), 17·6 turns per inch.

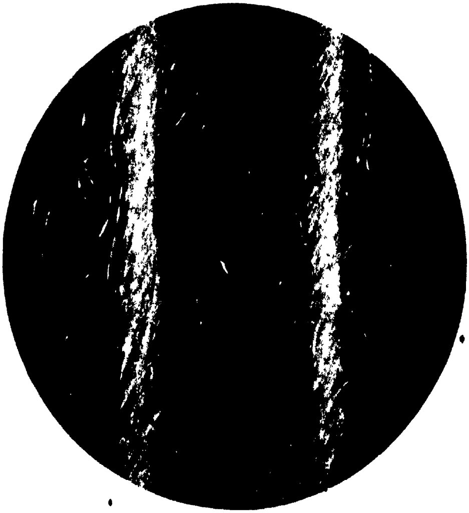


Fig. 39a.—8's Worsted Yarn (Southdown Wool), 12·9 turns per inch.

of milling. The firmer a thread, due to the degree of twist or twine, the less its felting property. Twine also apparently diminishes the diameter of the thread, as seen in Figs. 38 and 38A, both of which are yarns made of Southdown wool, from the same size of condensed sliver, and spun to 18 yards to the dram; so that any structural difference is a product of spinning alone. Twine, however, does not modify the average number of fibres in the yarn, nor yet the counts or the relation of the length to the weight, but it does affect (1) the actual diameter by compressing the fibres into closer contact with each other; (2) the solidity of the thread; and (3) its felting quality.

A number of experiments have been carried out in various fabric structures, materials and counts of yarn. These show the degree in which fabric contraction is controllable by the amount of twine in the yarn. One series in which Saxony, Cheviot and Pulled Waste were used may be analysed. The fabrics were made with a cotton warp, 2/20's, set 14½'s reed 2's, and 36 inches in the reed. The counts of the weft yarn was 10 skeins, and the turns per inch, breaking strain and elasticity are stated below:—

TABLE VI.

BREAKING STRAIN AND ELASTICITY OF YARNS MADE OF TASMANIAN AND CHEVIOT WOOLS, AND PULLED WASTE.

Material.	Turns per inch.	Breaking Strain in Grammes.	Elasticity.
Tasmanian Wool .	11·33	1,105	3·76 ins.
" " . .	7·50	1,030	3·30 "
Cheviot " . .	9·00	924	3·00 "
" " . .	5·25	750	2·40 "
Pulled Waste . .	11·40	787	2·35 "
" " . .	6·20	607	1·65 "

Three weaves typical of fabric structure were used, and the relative shrinkages are given in the following table:—

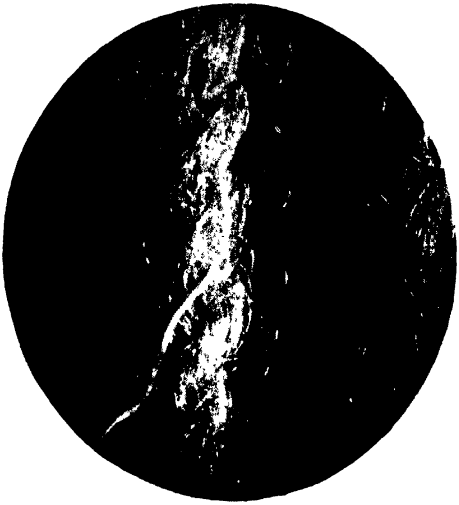


Fig. 40.—2/18 skeins Woollen Yarn (Southdown Wool), 9·7 turns per inch.

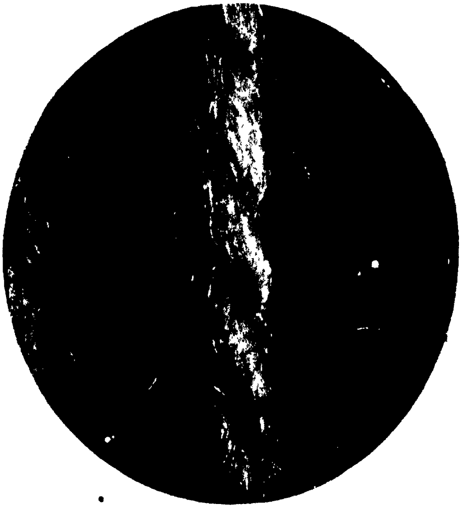


Fig. 41.—2/8's Worsted Yarn (Southdown Wool), 8·6 turns per inch.

TABLE VII.

CONTRACTIONS IN FABRICS MADE OF YARNS OF DIFFERENT DEGREES OF TWINE.

Weaves.	Tasmanian Wool.		Cheviot Wool.		Pulled Waste.	
	Twine.		Twine.		Twine.	
	Hard.	Soft.	Hard	Soft.	Hard.	Soft.
Plain .	37·50	41·75	34·75	36·00	30·50	33·25
$\frac{2}{2}$ twill .	39·00	44·25	39·00	44·25	36·00	41·75
Swansdown .	41·50	47·25	41·50	44·25	37·50	40·25

Taking the Tasmanian, which is the highest felting material, he difference in contraction between hard and soft twine is 4·25 per cent. in the plain weave; 5·25 in the twill; and 5·75 in he swansdown.

The theory underlying these results is, that the felting quality of a yarn is affected by the degree of twine inserted. Worsted fabrics are subject to similar felting changes when made of yarns differing in this particular. The measure of contraction in these experiments is only slightly variable in the three materials, showing that with a corresponding unit of difference in twine, such as is necessary in the several qualities of fibres used, there is approximately the same ratio of difference in the felting of the fabrics.

The dissimilarity between the Cheviot and the Tasmanian is caused by the length and nature of the fibres in each yarn. As, however, the comparison is not between the felting of fabrics made of different materials, but between yarns varying in twine, this does not affect the results.

It should be noted that by prolonging the period of shrinkage, or the process of fulling, it is possible to gradually expand the felting power of hard-spun threads, but this does not destroy the hardness of handle which the cloth possesses. A fair degree of felting is produced in this way, but the textural quality is not satisfactory.

(47) *Folded Yarns and Shrinkage.*

Doubling or folding two or more yarns is another element which has an important bearing upon the fulling strength of the cloth. If doubling results in a firmer thread than the separate yarns used, the felting property of the fabric suffers. The process of folding may be done in three ways; (1) by twisting the several yarns in the same direction as the original twine, which produces a hard, unyielding yarn of reduced felting quality; (2) folding may eliminate a number of turns in the single yarn, giving as a result a yarn soft in structure; and (3) it may reduce the amount of twine in one or more threads and increase the same in others. Complex felting conditions are thus induced by folding or twisting several threads together. Certain of these factors may be auxiliary, and others deterrent in nature, during the felting of the cloth; but one law, operative in yarn structure, whether in single or compound threads, in relation to felting, is that the less the degree of twine the greater the degree of felting quality.

CHAPTER V.

THEORY OF FELTING: FABRIC STRUCTURE.

(48) Build of the Fabric. (49) Felting Quality of Standard Weaves. (50) Influence of Intersections. (51) Variation in Wefting. (52) Irregular Weaves and Felting. (53) Felting of two-ply Warp and Weft Fabrics. (54) Relative Shrinkage of Single and Backed Weaves.

(48) *Build of the Fabric.*

In addition to the measure of fabric contraction, in scouring and felting, being dependent upon the quality of the fibre and the structure of the yarn, it is also affected by the system of interlacing warp and weft in weaving; and it is the latter which has now to be considered.

Weave structure, as it influences fabric milling, forms a subject for experimental research. Experience in manufacturing has discovered and utilised the correct types of weaves for special milling work, *e.g.*, in beaver, melton, doeskin and other cloths; but fuller information is wanting on many aspects of the subject. For instance, it is well understood that one active controlling element in the process of fulling a woven fabric, is the frequency of the interlacings of the warp and weft. Moreover, it is also obvious that this is affected by such technical features as (1) the ratio of threads to picks, or relative compactness of warp and weft; (2) the relative diameters of the yarns; and (3) the fibrous materials of which the yarns are composed, and their several positions—face, centre or backing—in the woven structure; and also by the use of methods or practices in manufacturing differing from each other in nature and result.

In regard to fabric structure, it is as diversified as the possibilities of the process of weaving, and the range of materials and yarn construction.

Weaving possibilities afford unlimited structural diversity in (1) single cloths; (2) in fabrics multi-ply in the warp, weft or both; and (3) in special builds of fabrics. In each of these types of woven textures felting experiments have been carried out.

As to the range of materials and yarns, and their effects in the milling of the cloth, some data have been ascertained, as, for example, on the felting qualities of woollen and worsted yarns, and the effect of degrees of twine; but as the methods of mixing yarns in warp and weft, and of using them in weaves of different structure, are so diversified, they form another field for technical analysis and research.

(49) *Felting Quality of Standard Weaves.*

The effect of weave on the felting power of the fabric is distinct from the nature of the material or the yarn. This does not imply that a given structure of weave is not affected in felting degree by a change in quality of fibre, but rather that the contraction, in any material, is also determined by the method of intertexture. For example, comparisons in such standard weaves as the plain; angled prunelle; $_{2}\text{—}^{2}$ and $_{3}\text{—}^{1}$ twills; and broken swansdown, prove that the degree of shrinkage is governed (*a*) by the number, and (*b*) by the order of warp and weft intersections. Both the number of interlacings, and the system of grouping, operate on the contraction of the fabric. With the exception of the angled prunelle, the intersections are regular on each thread and pick of the weaves named. Assuming the setting in the warp to be the same for the five weaves, the unit of measurement would vary with the number of threads between the intersections. Thus, taking 30 threads per inch in the fabric from the loom, then the unit in the plain weave would be 1/30th; in the $_{2}\text{—}^{2}$ twill 1/15th; and in the $_{3}\text{—}^{1}$ twill two units, namely, 1/10th and 1/30th in succession. A fixed law in fabric structure is, the greater the unit the freer the process of fabric shrinkage. In Table VIII., the experimental results are given, in the several weaves produced in Saxony and Cheviot yarns, in two degrees of twine. They illustrate the effect of weave on shrinkage in these materials and yarn structures.

Abstracting the shrinkages on the five weaves, and converting them into percentages based on the reed or loom width, they are as follows:—

Weave.	Percentage of Shrinkage in Saxony Yarns.	Percentage of Shrinkage in Cheviot Yarns.
Plain . . .	29·00	22·25
Angled Prunelle .	34·75	30·50
$\frac{2}{2}$ twill . .	33·35	27·25
$\frac{1}{3}$ twill . .	34·75	27·25
Swansdown . .	34·75	30·50

(50) *Influence of Intersections.*

A primary cause of these differences in shrinkage is, as stated, the build of the fabric. A change in the grouping of the intersections effects a change in the amount of contraction. But this only partially explains the felting, for whereas in Table I., the angled prunelle has a slightly less shrinkage than the $_{2}{}^{2}$ twill fabric, in Table VIII., where the setting, counts of yarn, and picks per inch are different. the felting results in these two weaves are changed. The ratio of picks has some influence. In this series of experiments there are 24 picks per inch in the plain weave, 28 in the angled prunelle and 33 picks per inch in the other weaves.

It has been shown that the number of intersections and the system of planning are both factors which determine the amount of shrinkage. The number is obtained thus: Intersections per inch multiplied by reed width in inches, multiplied by picks per inch: giving in the setting named in Table VIII., 25,920 intersections in the plain weave; 20,160 in the angled prunelle; and 17,820 in the $_{2}-{}^{2}$ and $_{3}-{}^{1}$ twills in one inch of fabric, 36 inches wide. Thus, there are approximately 45 per cent. more intersections in the plain than in the twill, and 28 per cent. more than in the angled prunelle. How these modify the felting of the fabric is instanced in the Shrinkage Table VIII. The plain weave has minus 5·75 per cent. of felting power as compared with the angled prunelle, and minus 4·35 per cent. as compared with the $\frac{2}{2}$ twill, though the latter has less intersections than the angled prunelle. The similarity of the shrinkage quality of these two weaves is due to the method of grouping the intersections. In addition, the warp is cotton, so that the shrinkage is only on the weft. If the warp had been woollen, then the felting power would have been more in favour of the $\frac{2}{2}$ twill. The point is, that while it follows in regular weaves, that the ratio of shrinkage corresponds with the ratio of intersections, yet in this example, it is clear that the system of arrangement is also a neutralising quantity. Each third pick in the angled prunelle twill draws the warp threads together in sets of three, acting in a like manner to a weave of the weft cord type; and any such condition assists and accelerates felting. There are no corresponding relations of warp and weft in the $\frac{2}{2}$ twill, the threads being crossed in pairs, and the movement progressive and not constant or in the same line.

Another example of a different character, of the influence of the order of grouping the intersections, is that of the $\frac{2}{2}$ twill and broken $\frac{1}{3}$ twill. The intersections are now identical in number, yet the shrinkages are excessive in the latter.

TABLE IX.

SHRINKAGE IN $\frac{2}{2}$ TWILL AND $\frac{1}{3}$ BROKEN-TWILL FABRICS.

	$\frac{2}{2}$ twill.	Broken $\frac{1}{3}$ twill.
Saxony: hard spun	33·25	34·75
Cheviot: „ „	27·75	30·50
Saxony: soft spun	36·00	39·00
Cheviot: „ „	30·50	31·75

The explanation here is that in the twill the movement, as stated, is progressive, pick 1 linking threads 1 and 2; pick 2, threads 2 and 3; whereas in the swansdown, picks 1 and 4 link threads 1 and 3, and picks 2 and 3 link threads 2 and 4.

Three of the principal elements in weave affecting felting are presented in these comparisons: (1) That when the intersections are in regular order, the less the number, the greater the felting property—all other conditions being the same—of the fabric; (2) it is possible to divert this law and reverse the result by the method of arranging the intersections; (3) in weaves of identical intersections the felting results vary according to the manner in which the same threads are grouped by successive picks.

(51) *Variation in Wefting.*

To illustrate in what way, and to what degree, the contraction in scouring and milling is affected by the density of the fabric, or, in this instance, by the variation in the number of the picks per inch, Table X. is given. It is based upon experiments in the plain weave, ${}_{2}{-}^{2}$ mat, and ${}_{4}{-}^{4}$ mat, each woven with 10 skeins weft, the warp being 2/20's cotton, 30 ends per inch.

Taking, for example, the plain weave, ${}_{2}{-}^{2}$ mat and ${}_{4}{-}^{4}$ mat, the percentages of shrinkage calculated from the reed width are as follows:—

TABLE X.

SHRINKAGE IN FABRICS MADE IN PLAIN WEAVE, ${}_{2}{-}^{2}$ AND ${}_{4}{-}^{4}$ MATS.

Picks per inch.	Percentage of Shrinkage from Reed Width to Milling 90 Mins.		
	Plain Weave.	${}_{2}{-}^{2}$ Mat.	${}_{4}{-}^{4}$ Mat.
18	55·4	—	—
24	47·3	55·4	—
32	39·2	50·0	56·7
42	30·0	43·2	55·4
58	—	—	52·7

It will be noticed that the percentages vary from 47·3 in the plain weave (24 picks per inch) to 50 in the $\frac{2}{2}$ mat (32 picks), and 55·4 in the $\frac{4}{4}$ mat (42 picks). The percentages in the plain decrease with each number of picks per inch from 8 to 9; in the $\frac{2}{2}$ mat from 5 to 7; and in the $\frac{4}{4}$ mat from 1 to 3.

(52) *Irregular Weaves and Felting.*

Research in several varieties of textile structures—both yarns and fabrics—has been carried out to determine the effect of weave on the felting quality of the cloth. In one series, two warps (2/16 skeins woollen and 2/7's worsted) were crossed with 12 skeins woollen and 5½'s worsted, forming separate pieces. As far as practicable, in spinning on the two systems, the yarns were made to the same counts and with similar turns per inch, as indicated below:—

TABLE XI.

WARP YARNS.

Woollen.			Worsted.		
Counts	Turns per inch.	Yds. per lb.	Counts.	Turns per inch.	Yds. per lb.
2/16 skns.	5·1	2,048	2/7 's.	5·8	1,960

WEFT YARNS.

	Woollen.			Worsted.		
	Counts.	Turns per inch.	Yds. per lb.	Counts.	Turns per inch.	Yds. per lb.
A. Soft spun .	12 skns.	6·3	3,072	5½ 's.	6·1	3,080
B. Hard spun .	12 skns.	10·6	3,072	5½ 's.	10·6	3,030

Both warps were set 24 ends per inch in the reed and the following weaves were used:—

No. 1. $_{2}-^{2}$ twill.
,, 2. $_{2}-^{2}$ twill cutting two's.
,, 3. $_{2}-^{3}$ twill.

In this manner four fabric structures were obtained, woven respectively in (*a*) woollen warp and weft; (*b*) woollen warp and worsted weft; (*c*) worsted warp and weft; and (*d*) worsted warp and woollen weft. According to the theory deduced, *viz.*, that weave is an initial controlling factor in the milling process, the maximum shrinkage should be in Weave 3, and the minimum in Weave 2. This was actually so in each series of textures. There was, necessarily, an appreciable difference in the degree of felting in fabrics woven with hard and soft spun wefts, but the ratio of shrinkage was invariably highest in Weave 3 and lowest in Weave 2. Table XII. gives the results in the woollen weft fabrics.

TABLE XII.

SHRINKAGE RESULTS ON FABRICS WOVEN WITH HARD AND SOFT SPUN YARNS.

Plan No.	Picks per inch.	Wefts.	Percentage of Shrinkage.	
			Woollen Warp.	Worsted Warp.
1	26	12 skns.[1]	[illegible]5·50	32·25
2	27	,,	32·25	30·50
3	33	,,	38·50	37·00
1	26	12 skns.[2]	32·25	30·50
2	27	,,	29·00	29·00
3	33	,,	35·50	35·50

[1] *Soft spun yarn.* [2] *Hard spun yarn.*

The weaves so far examined are elementary in structure. In a second series of experiments, weaves of a more irregular type were applied, namely, those in Fig. 42. As in the preceding examples, two warps and wefts—woollen and worsted—were used, namely.—

TABLE XIII.

	Counts.	Turns per inch.	Sett.
Warp I. . .	2/20 skns. woollen	9·7	36 ends per in.
„ II. .	2/8's. worsted	8·6	„
Weft I. . .	12 skns. woollen	13·8	
„ II. .	8's. worsted	12·2	

In Table XIV. the percentages of shrinkage in the several weaves and yarns are stated.

TABLE XIV.

PERCENTAGE OF SHRINKAGE OF FABRICS IN SEVERAL WEAVES.

Plans.	Wefts.	Picks.	Percentage of Shrinkage. Period 90 Minutes	
			Warp I.	Warp II.
Fig. 42				
A	12 skns.	32	32·25	32·25
B	„	32	22·50	22·50
C	„	28	22·50	22·50
D	„	34	33·75	32·25
E	„	26	22·50	22·50
A	8's.	32	32·25	29·00
B	„	32	22·50	19·25
C	„	30	22·50	22·50
D	„	36	33·50	32·25
E	„	29	22·50	19·25

Comparing, in the first place, the shrinkage in Plans A and B, that of the former in both woollen and worsted wefts exceeds that of the latter by 10 per cent. The picks per inch being the same in the two weaves, there is no textural condition accounting for this difference in shrinkage but that of weave structure. Examining the intersections, there are eight on each pick in twenty threads in Plan A, and in Plan B, ten on certain picks and eight on others, in twenty threads. The intersections are, therefore, not sufficient to cause this comparatively high shrinkage property of the fabric due to Weave A. The reversing or angling of Weave B is a feature which has diminished the shrinkage quality of the cloth. The movement to the right and to the left alternately of the twilled mat, on such a limited number of threads, lessens the felting character of the fabric.

The effect of this influence of weave structure on felting is further exemplified by Plan C. Here, there are the same intersections as in Plan A, but there is again a difference of approximately 10 per cent. in felting between the fabrics resulting from Weaves A and C respectively: from which it is apparent that in addition to the intersections, a further element in weave structure is determining the felting property of the cloth. Weave C is reversed in both warp and weft, forming a cut check, and this interchanging or reversing has so far reduced the shrinkage quality of the fabric, that with the intersections the same as in Weave A the felting is diminished, as stated in Table XIV. by 10 per cent.; or it is the same, practically, in Warp I as Weave E, which possesses one-third more intersections, but these arranged in regular twill order.

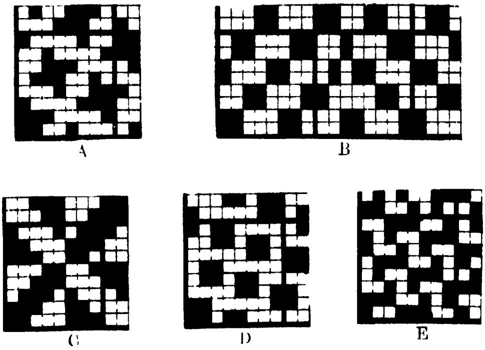


Fig. 42.

The highest shrinkage, it will be observed, is in Weave D, though the intersections are similar to those of Weave A. They are as follows:—

Weave A.	3 weft,	4 warp,	1 weft,	2 warp.
Weave D.	2 weft,	1 warp,	2 weft,	5 warp.

There are, thus, four types of intersections in A, and three types in D, with the maximum intersections in A, comprising four threads, and in D, five threads. It is these differences in the order and kind of intersections which produce in these weaves, cloths of different milling quality.

(53) *Felting of Two-ply Warp and Two-ply Weft Fabrics.*

Several of the principles of intertexture affecting the shrinkage of fabrics single in structure, are common to fabrics two-ply in either warp or weft. The supplementary set of yarns is, however, a complicating factor. It follows, the more intricate the fabric structure, the more numerous the technicalities controlling the felting process.

Backed cloths are intermediate between single and double cloths. In regard to felting, they offer a structure more difficult of analysis than the former, and less difficult than multiply fabrics. In one direction of the texture, there are two series of yarns lying one over the other, bound together by a third series, appearing alternately on the under and upper surface. Of these two series, one is limited to each side of the fabric. The scheme of weaving may be the same or dissimilar in the respective yarns. In the case of the weaves being the same, the shrinkage quantity is affected by similar principles to those applicable to single weaves, with one additional influencing factor, namely, the binding or stitching of the face and backing yarns into the same fabric. Should, however, the backing weave be of a different structure to the face weave, it may increase the felting quality of the fabric. If, for example, the ${}_{2}{-}{}^{3}$ twill should be backed with a 10-end sateen—a comparatively loose but regular back—the sateen would increase the shrinkage quality of the cloth. In fabrics in which the face weave is regular, and the backing weave irregular, or both irregular in structure, the possible contraction can only be fixed by experiment.

(54) *Relative Shrinkage of Single and Backed Weaves.*

For a comparison of this nature, backed textures with the same weave on both surfaces are the most suitable. In such cloths, the underside is a duplication of the face with certain changes in setting. In Fig. 43 the shrinkage curves are

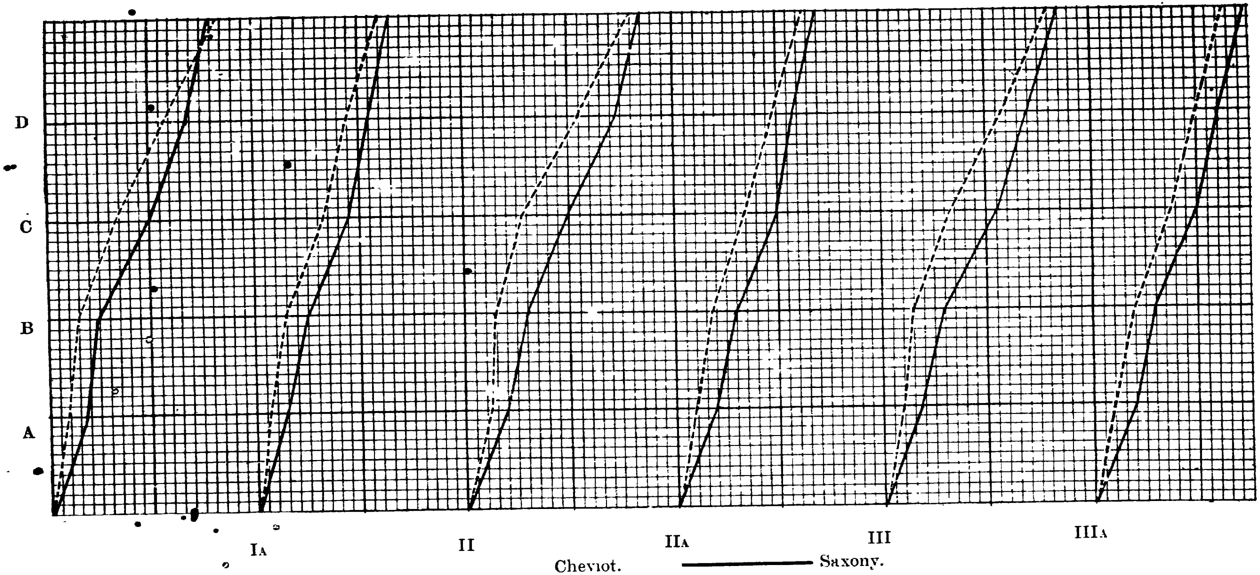


FIG. 43.—COMPARISON IN SHRINKAGE CURVES, SINGLE AND BACKED WEAVES.

A = Line of contraction from loom.
B = " " after scouring.
C = " " " milling 30 minutes.
D = " " " " 60 "
E = " " " " 90 "

I = Prunelle twill.
IA = Backed prunelle.
II = $_{3}^{1}$ twill.
IIA = " backed.
III = Broken $_{3}^{1}$ twill.
IIIA = " " backed.

drawn of the prunelle, $\frac{1}{3}$ twill, and broken swansdown, in both single and backed fabrics. The contraction on lines A, B and C corresponds in the types of texture in each of the weaves; showing that in these examples, the difference between single and backed cloths does not result in any disparity in shrinkage, in the processes of scouring and preliminary milling; but in the periods of felting indicated on lines D, E and F the behaviour of each kind of structure is distinct.

The following are the units of shrinkage as represented by the diagram (Fig. 43):—

TABLE XV

COMPARATIVE SHRINKAGES OF SINGLE AND WEFT-BACKED FABRICS IN SAXONY (S.) AND CHEVIOT (C.) YARNS

Periods of Contraction.	Units of Shrinkage in Inches:											
	Prunelle.				Swansdown.				Broken Swansdown.			
	Single.		Backed.		Single.		Backed.		Single.		Backed.	
	C.	S.	C.	S.	C.	S.	C.	S.	C.	S.	C.	S.
A	2	3½	1¼	3	2¼	4	2	4	2	3¾	2	4
B	3	5	3	5	3	6	3½	6	3	6	4	6
C	6½	10	6½	9	5½	10	7	10	6½	11	7½	10
D	11	13½	9	11	11	14½	9½	11½	11½	14	10	12
E	16½	16	12	13	16	17	12½	14	16	17	12½	14

In each of these standard examples there is an excessive shrinkage in favour of the single weaves of from 3 to 4 units. The two structural elements at the base of this are (1) the simpler grouping of the intersections in the single weaves; and (2) the binding of the two weft surfaces together, strictly two textures, in the backed weaves: which, whilst not adding to the number of intersections on the picks, inserts a textural condition which detracts from the felting quality of the cloth. The results in Table XV. show that the ratio of shrinkage between the two types of weave is the same in both Cheviot and Saxony yarns, and also that in cloths of the weft reversible character, the difference in the degree of felting is approximately the same though the weave structure may be varied. Thus (Period E), in the prunelle (Saxony yarns), in the single weave, there are sixteen units of shrinkage, and thirteen units when backed; in the broken swansdown (Saxony yarns) single weave, seventeen units, and fourteen in the backed weave; that is to say, a difference of one unit of shrinkage between the two types of weave, but in both a difference of three units of shrinkage between single and backed.

A deduction which follows is, that the changing of a single weave into a reversible—1 face, 1 backing—diminishes the felting property of the cloth. This takes place even if the number of picks per inch in either of the two surfaces of the backed fabric, is less than in the single structure. The picks per inch were in the single swansdown 33, and in the backed weave 58, with the same yarns and setting. Removing one of the wefts—face or backing—would leave a single texture with 29 picks per inch, and of similar felting quality to the single swansdown cloth, but the binding of the two layers of yarn together in the backed weave reduces the felting result.

CHAPTER VI.

THEORY OF FELTING: COMPOUND FABRICS.

(55) Structure of Backed Fabrics and the Felting Quality of the Cloth. (56) Three-ply weft Fabrics. (57) Yarn Characteristics in Compound Weft Fabrics. (58) Fabrics Compound in the Warp. (59) Felting of Compound Weaves. (60) Double Cloths and Varied Felting. (61) Stitching or Tying of Double and Compound Weaves and the effects on Milling.

(55) *Structure of Backed Fabrics and the Felting Quality of the Cloth.*

THE method of constructing backed and compound weaves, as to the order of the face and backing yarns, may have an appreciable effect on the felting of the fabric. This is the case if the order of face and backing yarns alters the number of intersections in the backed weave. When, for example, the swansdown and eight-shaft sateen are arranged 1 pick face and 1 pick backing or 2 picks face and 2 picks backing, the order of wefting does not, in certain counts of warp and weft yarns, setting, and picks per inch, modify the felted result.

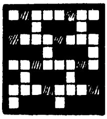


FIG. 44.

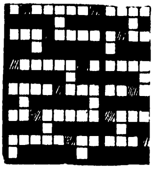


FIG. 45.

The same features affecting felting in single weaves apply, with some variation, to weaves of the backed type. The interlacings of the warp and weft are a controlling element. For instance, in the backed swansdown (Fig. 44) and the backed six-end sateen (Fig. 45), there is a difference of two intersections in ten threads, yet in the same fabric setting (reed, picks per inch and yarns) the milling in the latter (woollen yarn) was 35·6 per cent, and in the Crossbred worsted yarn 31·5; whereas in the former (woollen yarn) it was 28·7 and in the Crossbred worsted 23·2 per cent.

The weave applied to the back also varies the felting quality of the face cloth. As suggested, the looser and more open the backing weave the greater the measure of contraction in a definite period of milling. The four-shaft twill, backed with a three-and-one weave, gives a fabric of different felting property to the same weave backed with an eight-end sateen. The following are shrinkage results in the two weaves, the counts of warp and weft yarns and setting being alike, with an increase of eight picks per inch in the twill backed with sateen.

TABLE XVI.

Weft.	$\frac{2}{2}$ Twill. Backed with $\frac{1}{3}$ Twill.	$\frac{2}{2}$ Twill. Backed with 8-end Sateen.
Cheviot yarn .	35·0 per cent.	40 per cent.
Saxony ,, .	38·8 ,, ,,	43 ,, ,,

The sateen-backed weave has here an increase shrinkage value of 5 per cent. in both kinds of yarn.

(56) *Three-ply Weft Fabrics.*

In three-ply weft fabrics, several conditions obtain distinct from ordinary backed fabrics. Weaves differing in fineness and fastness may be used for the three textures. The face cloth may be fast, the centre medium, and the back loose woven; or the face medium, and the centre fast woven.

Figs. 46 to 50 are examples in three-ply weft weaves, and Figs. 46A, 48A and 50A, sections showing the interlacings of warp and weft yarns in such fabrics.

An eight-end twill forms the face, and a two-and-two twill the centre in Fig. 46; and an eight-end sateen and back, with two-and-two twill centre, the face and back in Fig. 47. Figs. 48 and 49 are similar to Figs. 46 and 47 with the centre weave plain. Fig. 50 has a four-and-four twill centre.

Theoretically, the weave Fig. 50 should have the highest, and the weave Fig. 48 the lowest shrinkage property. Milling experiments gave 51·4 per cent. shrinkage in Fig. 46; 52·72 in Fig. 47; and 41·66 in Fig. 48, on a period of ninety minutes.

The effect of the weave structure will be better understood from the sectional drawings. The relation of the picks to the threads in Figs. 46A and 48A, produces fabrics distinct in structure. The face and backing weaves are the same, but the plain weave in the centre of Fig. 48A, makes a faster build of fabric than the two-and-two twill in Fig. 46A. On the other hand, the $_{4}{-}{-}^{4}$ twill centre in Fig. 50A gives a looser or more open fabric structure. The relative firmness of texture, due to the frequency of the warp and weft interlacings, is plainly seen in Figs. 46A, 48A and 50A.

Milling quality in three-ply weft cloths is determined by the structure of each of the three weaves; that is to say, the face and backing weaves in the two cloths may be the same, but if in one the centre be plain and in the other twill, the latter being the looser structure has the greater felting quality.

(57) *Yarn Characteristics in Compound Weft Fabrics.*

The diversity of felting produced by the different types of weave indicated, is of practical utility in the manufacture of certain varieties of fabrics. This is rendered more valuable by the application to each weave, in two or three-ply cloths, of yarns of dissimilar felting qualities. Worsted yarn may be used for the face and woollen for the backing fabric; or fine woollen twist yarn for face and soft spun woollen yarn for back. There are also makes of backed cloths in which the same yarn is used for both sides, but if different, as indicated, the higher quality of yarn will, more or less, according to the structure of the weave, control the felting.

Take, for example, a worsted face and woollen back fabric. The woollen being usually softer spun than the worsted

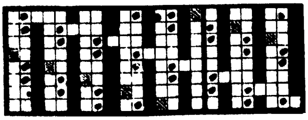


FIG. 46.

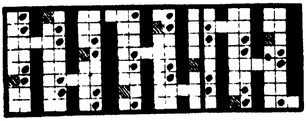


FIG. 47.

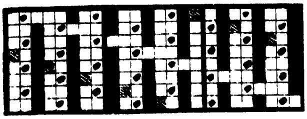


FIG. 48.

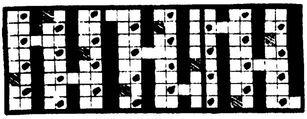


FIG. 49.

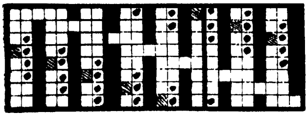


FIG. 50.

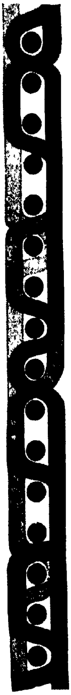


FIG. 46A.

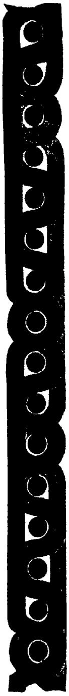


FIG. 48A.

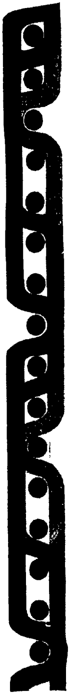


FIG. 50A.

FIGS. 46 to 50.—THREE-PLY WEFT WEAVES.
FIGS. 46A, 48A, 50A.—SECTIONS OF THREE-PLY WEFT FABRICS.

should increase the shrinkage of the face cloth made of the worsted yarn. On the other hand, if worsted were used for the face and a coarse quality of shoddy for the back, the shrinkage on the worsted would scarcely be affected by the backing yarn. But in cotton warp and worsted weft-face unions, with a medium quality of mungo for back, the looser interlacing of the backing weave should add to the degree of felting due to the worsted face yarn.

Fig. 33, referred to in Paragraph 41, is a fabric consisting of the three-ply weave (Fig. 51) which has an eight-end sateen face, a plain weave centre and a sixteen-end sateen back; three weaves of distinct shrinkage values. By using a worsted or lustre yarn for face, cotton for the centre and fine woollen for the back, the weave structures and qualities of the yarns increase the disparity of felting between the face and backing textures. In the milling process, the Saxony yarn—loose weave structure—rapidly forms a clothy felted surface, but the faster weave on the face and a material of less felting property, cause the lustre yarn to loop or buckle. The greater the difference in the weave structures and also in the quality of the materials for face and backing, the more definite the curly characteristic. If, on the other hand, the face yarn were Cheviot, and the backing fine wool, there would possibly be no greater difference between the two weaves, or the Cheviot and Saxony textures, due to felting, than that the former would have the characteristics of a milled serge and the latter of an ordinary Saxony.

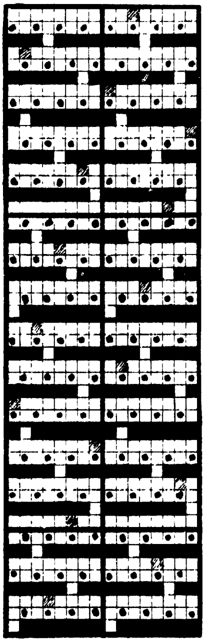


Fig. 51.

Another application of this type of weave in relation to milling is in heavy cloths for overcoatings and mantles, with a serge yarn for the face, and a yarn of finer material but not pure wool, for the back. The distinct felting property of the materials is to give character to the compound fabric, namely, the bright yarn a clear serge effect, and the mungo yarn a surface which may be raised and covered with fibre after milling.

(58) *Fabrics Compound in the Warp.*

Fabrics, compound in the warp, correspond in structure to fabrics compound in the weft, threads of warp taking the place of picks of weft, and the cloths being two or more fold in the warp and single in the weft. Warp-backed cloths, in which a wadding weft is used, afford additional points for consideration in felting, because the wadding may be woollen and soft spun, for imparting thickness and milling property to the cloth; or, it may be a thick cotton yarn, in which instance it would reduce the milling property due to the woollen or worsted yarns making the face and backing fabrics. But the ordinary types of these cloths are single in the weft and unwadded, hence if the structure and order of the yarns are the same as in the weft-backed cloths described, the milling results should be similar, but changing the shrinkage from weft to warp of the piece. For example, in weft-backed fabrics, with a *cotton warp*, the shrinkage in length is almost *nil*; whereas in warp-backed fabrics, with a *cotton weft*, the shrinkage would be chiefly in the length, and only to a small degree in width.

Three of the principal types of warp-backed fabrics in relation to milling are:—

I. Reversibles, fabrics with the same weave for face and back; *e.g.* (*a*) face and backing warps worsted, and woollen weft; (*b*) face and backing warps and weft woollen (Fig. 52).

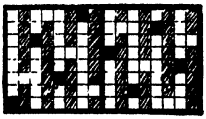


FIG. 52.

II. Fabrics with faster weaves for the face than the back; *e.g.*, two-and-two twill face and sateen weave for back, and made in similar or different qualities and counts of yarn for warp and weft (Fig. 53).

III. Fabrics threefold in the warp and single in the weft;

e.g., sateen face and back, and a finer weave, such as two-and-two twill for centre (Fig. 54).

I. In warp-backed fabrics, in which worsted warp and woollen weft are used, shrinkage may be in both length and width, but if the smartness and character of the worsted face are to be distinctive of the finished cloth, then the felting should be more in the direction of the weft than the warp. When woollen warp and weft are used for a face-finished cloth, the felting may be equally on the length and width, though both sides of the fabric (Fig. 52) consist of warp yarn, and the weft passes between the face and backing threads.

II. In the second class (Fig. 53), with finer weaves on the face than on the back, should the felting be chiefly on the warp, the backing weave would be an influencing factor. For instance, a $\frac{2}{2}$ twill fabric, single weave, would shrink in the same period, less in length than the backed weave, the comparative looseness of the backing weave, and also the quality of the backing yarn, making the difference in the felting of single and compound fabrics.

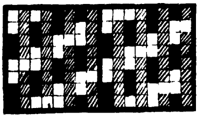


FIG. 53.

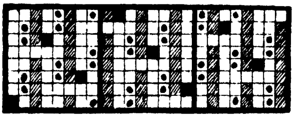


FIG. 54.

III. Three-ply warp cloths may be arranged in a similar way to three-ply weft fabrics as to weaves for face, centre and back. Taking the example (Fig. 54), the milling on the length of the piece would be similar to that of a single cloth, but for the stitching of the three layers of warp together, and the centre weave; the centre weave being $\frac{2}{2}$ twill would be a deterrent, in the process of shrinkage, on the sateen face and backing textures. As in three-ply weft fabrics, by altering the face to a finer weave: the shrinkage on the length would be further reduced. The weft shrinkage in such fabrics is chiefly affected by (1) the relation of the weft to the face, backing and centre warps;

(2) the quality of the material used in each, warp,—woollen, worsted or cotton; and (3) the character of the centre weave.

(59) *Felting of Compound Weaves.*

Double and single cloths do not shrink alike in milling. They are distinct from each other in construction, and are also distinct in felting qualities. A double fabric, as the term indicates, is one consisting of two textures of the same or dissimilar yarns and structure. These are bound together by the threads and picks of one fabric, at regular intervals in weaving, interlacing with those of the other fabric. As to which cloth felts the better, under corresponding conditions, namely, a single or a double texture of precisely double the threads and picks per inch and of similar yarns, is influenced (1) by the method of stitching; (2) the arrangement of the weaves—face and backing—to each other; and (3) the measure of felting property developed in a cloth of double the density of threads to a single texture, but in all other data the same. These points can only be satisfactorily explained by the analysis of definite examples.

(60) *Types of Double Cloths and Varied Felting.*

The principal types of double cloths in which the degree of shrinkage is varied by the method of construction are as follows:—

I. Reversible cloths, with the same weave and counts of yarn and setting on both sides.

II. Cloths arranged one face, one backing, in both warp and weft, with different weaves, counts and quality of yarns for face and backing.

III. Cloths arranged two face, one backing, in both warp and weft, with the same weave on both sides, but of different counts of yarn.

IV. Cloths arranged two face, one backing, in both warp and weft, of distinct weaves, counts and qualities of yarns on each side.

I. *Reversible Double Cloths.*—These have the same weave, counts and qualities of yarn on both sides, so that the chief modifying element in felting is the method of stitching the two fabrics together. There are two layers of warp and weft exactly alike, each forming a separate fabric, and these, in weaving, are stitched or bound into one. There is, first, the felting of the warp and weft in each fabric, and second, of one fabric to the other. The process is compound. In reversibles,—the face and back exactly the same,—felting is regular or uniform in each texture: and not as in some double-make fabrics, where the backing texture may have a higher shrinkage property than the face, and *vice versa.*

Types II. and III., Double Cloths with Face and Back dissimilar.—These, as defined, are of two principal types, *viz.:* (1) Fabrics arranged one face and one backing in both warp and weft, with counts and qualities of the yarns different; and (2) fabrics arranged two face and one back, and irregularly, with the same or different counts of yarns and weaves for each side.

The first of these, constructed one face and one backing in both warp and weft, are made (*a*) with worsted yarn for face and woollen yarn for back; (*b*) solid worsted; and (*c*) face warp and weft worsted, backing warp cotton, and backing weft woollen; and also in other classes of yarns.

Each quality of yarn in a two-ply fabric exercises a specific effect in milling, but there is one rule applicable to the principal classes of these fabrics, namely, the yarn of the highest shrinkage property, as in other compound cloths, controls the degree of felting. Assuming, for example, the face warp and weft to be worsted and the backing woollen, should the latter yarn be of a fine quality of wool, it will increase the degree of shrinkage, in a given period, of the worsted fabric: this is done for a distinct purpose in manufacturing, as, for instance, in the construction of a fine cloth, the face being made of worsted yarns, and possessing, on the underside, the qualities of a milled woollen.

In producing suiting, coating and mantle cloths of this order, special regard has to be had to the setting. The worsted face fabric should be set a degree looser than if a woollen back were not to be applied. This allows of the shrinkage necessary without detriment to the smart clear finish of the worsted. Should the cloth be woollen, and twist warp for the face, and single yarn for the back, similar relative results might be obtained in felting.

Type IV., arranged two face and one back, or irregularly in both warp and weft.—The following are some of the principal of these fabrics: (*a*) worsted warp and weft for face, and woollen warp and weft for back; (*b*) worsted face warp, woollen face weft and woollen back; (*c*) worsted face warp and weft, cotton backing warp and woollen weft: and (*d*) single woollen yarn for face and twofold woollen yarn for back.

(*a*) *Worsted face and Woollen back.*—As the backing yarn is made on the carded principle, and is also softer in twine and thicker than the face, if the weaves should be the same for both face and backing cloths, felting would be improved. If a twill formed the face and a sateen weave the back, giving a faster structure on one side than on the other, the shrinkage of the cloth would be determined chiefly by the woollen yarns, which would also be the case in fabrics arranged three face and one backing, and irregularly such as two face, one back, one face, one back.

(*b*) *Worsted face warp, Woollen face weft, and Woollen backing.*—This is a standard method of making milled Vicuna cloths with a soft quality of finish. Three parts of the fabric being woollen, the shrinkage is chiefly affected by this yarn: but the face and the backing weaves have to be taken into account. Assuming an example, twill face and plain back, the face texture with worsted warp crossed with woollen weft would have approximately—if the quality of the material were the same—similar shrinkage property to the backing cloth made entirely of woollen. The relative results are determined by the setting of the face and backing yarns. It would follow that if the backing yarn were making a loose texture, and the face yarn a fast texture, the backing would have a tendency to give uneven shrinkage.

(*c*) *Worsted face warp and weft, Cotton backing warp, and Woollen weft.*—Here, as in other examples, the action of felting is determined by the quality of the wool used for the worsted and woollen yarns. On the other hand, the cotton warp detracts from the felting quality of the fabric, being bound to the worsted texture, and stitching, regularly, under the woollen weft. This diminishes the shrinkage, first, of the worsted in length, and second, of the woollen weft, so that the cotton warp operates in the milling process to the reduction of the degree of felting in both length and width of the fabric.

(*d*) *Single woollen yarn for face and Twofold woollen yarn for back.*—In the manufacture of golf cloakings, it is a practice to have a finer yarn for the back or lining than for the face, arranging the fabric one thread face to two threads backing or lining. If the weaves should be the same for both face and backing fabrics, the yarn for the former must be about double the thickness of that used for the latter. As such cloths are well milled—the specimen (Fig. 55) has been set 78 inches in the reed for 56 inches finished—they should be constructed of yarns, for each surface, of similar felting property. One method of doing this is to use a twist yarn for the back consisting of two threads of the single yarn forming the face. In this example, there is no special effect developed in milling due to the fabric structure; but in the selection of the yarns for the face and lining, if the folded yarn should be hard in twine, or not of the same material as the single yarn, irregular shrinkage of the two sides would result.

The points are (1) that when using yarns of different counts for each side of the fabric, to obtain evenness in milling, each counts or thickness of yarn must be of corresponding felting property; (2) that if one yarn is single and the other folded or twisted, it is desirable that the latter should consist of two or more threads of the single yarn, and the degree of twist must not produce a folded thread of such hardness as to reduce milling quality; (3) that in fabrics in which there is a necessary difference in the counts and quality of the yarn for face and lining, only moderate milling should be practised, and this regulated according to the difference in the character of the yarns used.

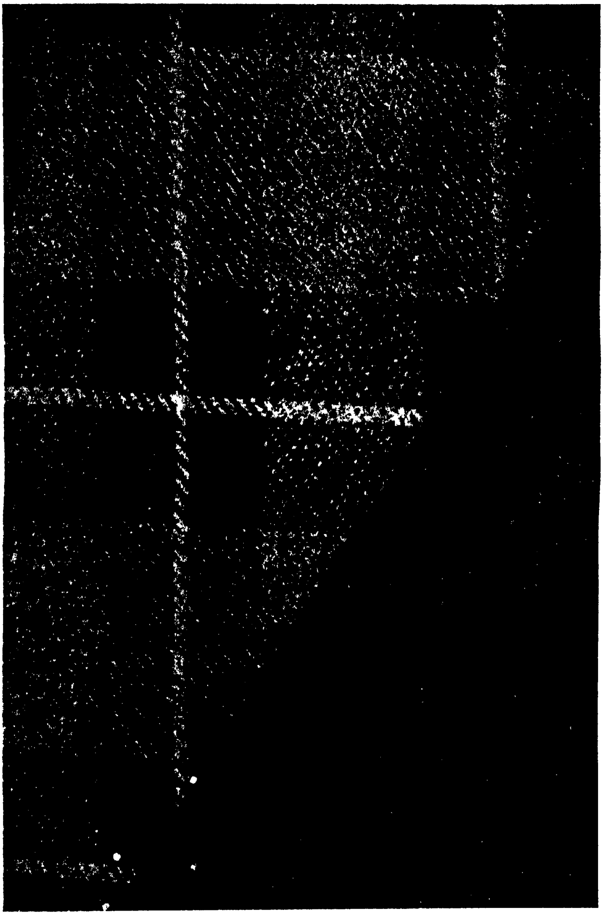


FIG. 55.

Golf Cloaking, with different pattern, yarns, and finish on each side.

(61) *Stitching and Tying of Double and Compound Weaves.*

In the various classes of compound weaves, stitching, or the system of binding two or more cloths together, operates on felting. It is a subject in which experimental research is needed. Some deductions may, however, be made from the series of examples given in Figs. 56 to 61. They are woven in 30 skeins yarn with 75 threads and 94 picks per inch, and treated alike in the milling process.

A comparison may first be made between Figs. 56, 57 and 58, the intersections on the face and backing threads and picks being as follows:—

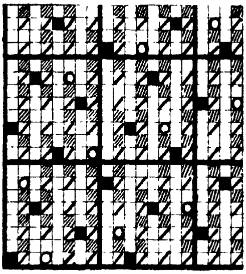


FIG. 56.—O = Warp stitches.

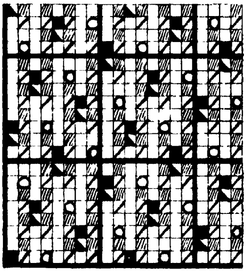


FIG. 57.—O Warp stitches.
◣ — Weft ,,

TABLE XVII.

INTERSECTIONS OF DOUBLE WEAVES.

	Intersections.			
	Threads.		Picks.	
	Face.	Back	Face.	Back.
Plan 56. Sateen face and back (warp stitched)	4	4	14	16
Plan 57. Sateen face and back (double stitched) . . .	4	4	12	12
Plan 58. Sateen face and twill back (warp stitched) . . .	4	8	14	12

The relative shrinkages in scouring and milling were:—

TABLE XVIII.

SHRINKAGES OF DOUBLE WEAVES.

	Scouring.		Milling.	
	Length.	Width.	Length.	Width.
Plan 56 . .	4·42	4·61	24·00	26·15
Plan 57 . .	4·71	4·68	18·86	17·18
Plan 58 . .	5·55	6·15	19·40	27·69

The shrinkage in scouring is given, but it is the milling shrinkage which is suggestive.

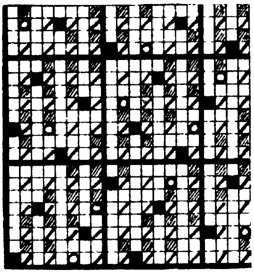


FIG. 58.—⊡ = Warp stitches.

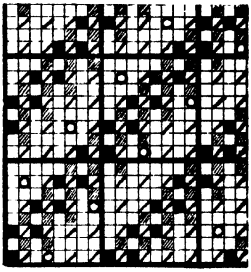


FIG. 59.—⊡ = Warp stitches.

Dealing, in the first place, with the fabric from Plan 57, there is a less shrinkage in width and length than in the fabrics from Plans 56 and 58. Still, it is the weave structure with the smallest number of intersections, and therefore, by the law of intersections, should give a cloth of the highest milling property. Stitching is, obviously, an additional influencing factor. The cloth is double stitched, that is, the face bound to the back with both threads and picks. The result is a firmer compound cloth than in single stitching, and one in which there is not the same facility of contraction in milling.

A further comparison of the effect of single and double stitching is supplied in Plans 59, 60 and 61, the intersections being:—

TABLE XIX.

INTERSECTIONS IN COMPOUND WEAVES, SINGLE AND DOUBLE STITCHED.

	Intersections.			
	Threads.		Picks.	
	Face.	Back.	Face.	Back.
Plan 59. Twill face and back (warp stitched)	8	6	10	12
Plan 60. Twill face and back (double stitched)	4	4	8	8
Plan 61. 10-shaft twilled mat (warp stitched)	8	6	10	12

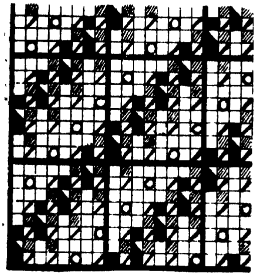


FIG. 60.—⊡ = Warp stitches.
◪ = Weft „

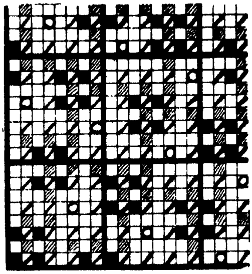


FIG. 61.—⊡ = Warp stitches.

The weaves are again the same on face and back with more intersections in the single stitched cloth, producing the following milling results:—

	Shrinkage in Length	and Width.
Plan 59	21·15	27·69
Plan 60	16·88	18·46
Plan 61	7·68	35·43

The value of stitching in modifying the effect of the interlacings is indicated by these examples.

Analyse, in the second place, Plans 56 and 58, and 56 and 61. The weft shrinkage in both Figs. 56 and 58 is about the same or only one degree less in Fig. 56 than Fig. 58. The intersections on the face and backing picks are given in Table XVII. Comparing the shrinkage in length, it is 24 per cent. in Plan 56 and 19·4 in Plan 58, the backing threads in the latter weave having eight intersections as compared with four intersections in Plan 56.

Plan 61 may be contrasted with Plan 56. It is a double 10-shaft weave, but the arrangement of the stitching is the same as in Plan 56. There is only 7·68 per cent. shrinkage on the length, but 35·43 on the width. There are eight intersections on the face threads and six on the backing threads, against four on each in Plan 56, making a difference of 16·32 per cent. more felting in the length in Plan 56 than in 61, but in width there is an increase in favour of the latter of 9·28 per cent. the intersections on the face and backing picks in Plan 56 being thirty, and in Plan 61, twenty-two.

In these comparisons, the ratio of shrinkage in length and width of the cloths from each weave is not considered, on account of the difficulty of securing the same pressure in the warp and weft directions in felting.

Double cloths may also be stitched with centre warp, or centre weft, when the principles explained in relation to ordinary stitching are applicable. If centre yarns are used for wadding purposes, the weave structure is not modified, these yarns lying between the face and backing fabrics, but they necessarily have an effect upon shrinkage according to the quality of material of which they are made. A woollen centre warp, for example, will increase the shrinkage property of a double fabric, whilst a cotton yarn will decrease this property in the cloth.

CHAPTER VII.

FULLING AND MILLING MACHINERY.

(62) "Fulling" and "Milling". (63) Routine in the Fulling Stocks and *Milling Machine.* (64) *Construction and Working of the Faller Stocks.* (65) Milling Machines. (66) Routine of Milling. (67) Corrugated Guide Rollers. (68) Machines with Two or More Upper Rollers. (69) Duplex Machines. (70) Machines without Flanged Roller. (71) Mechanical Devices applied to the Spout. (72) Roller Milling Machine with Stampers in the Spout. (73) Principle of Combined Milling Machine and Stocks. (74) Combined Scouring and Milling. (75) Milling without Artificial Compression.

(62) "*Fulling*" *and* "*Milling*".

THESE terms applied to fulling machinery have distinct meanings. Fulling relates mainly to the older form of machine or stocks, the design and construction of which were, no doubt, suggested by the method of tramping the cloth practised in ancient times. The term "Walker" was also used, and still obtains in the German "Walkmaschine". "Milling" is descriptive of all kinds of machinery in which the felting routine consists of a series of compressions on the piece or cloth. To full and to mill are technically synonymous, both denoting the working on the fabric to increase compactness, solidity and wearing strength. Still, "fulling" literally signifies, as the French "fouler," to tread, to press, as by the action of the stocks, and thus improve the density of the woven fabric by felting, whereas "milling" is more indicative of the treatment the cloth undergoes in the successive operations in the milling machine.

(63) *Routine in the Fulling Stocks and Milling Machine.*

By both methods pressure is applied to the cloth, but in distinct ways. When fulling in the stocks, the piece or pieces, having been prepared by soaping, are placed in the trough T (Fig. 62) in a roll or ball form. The movement of the cloth in this condition in fulling is one of turning under the hammering, pounding or tramping of the stock fallers. The process is simple in character. The same amount of force is directed on the length and width of the piece. Shrinkage decreases the superficial space occupied by the piece, and has the effect of increasing the distance traversed by the fallers, and the force of impact with the cloth. In other words, when the pieces are first put in the stocks they have the greatest bulk, the movement of the fallers being the minimum, but this increases with the felting. The bursting pressure (*i.e.* the fulling condition) is thus maintained.

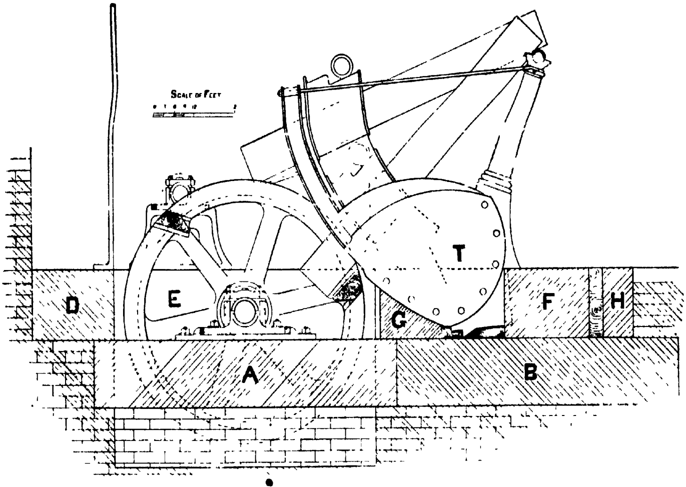


Fig. 62.

This routine may be contrasted with that characteristic of the milling machine. The felting on the length and width of the pieces is performed in separate parts of the machine, the process being a compound one. Firstly, as the piece, in a rope form, passes through a neck or guide and between a pair of squeezing rollers, the pressure is on the weft line of the fabric; secondly, the piece is cuttled and held momentarily in lengths in the spout, the lid of which is weighted according to the amount of felting required. There is, thus, compression on the weft, followed by compression on the warp direction of the cloth, under which there is, first, shrinkage mainly on the former, and second, mainly on the latter. In each process there is also some felting in both length and width.

Greater equality of felting, in warp and weft of the cloth, results in the stocks than in the milling machine. Another advantage of the stocks is less liability to produce marks and defects, particularly creases or mill rigs. Running the pieces in length, and necessarily in folds, in the ordinary machine, is sometimes the cause of rig marks, especially in Crossbred-yarn fabrics. If such faults commence at an early stage in milling, they may result in creases irregularly distributed throughout the piece. The chief advantage of the milling machine over the stocks is in economy, one machine doing the work of several stocks. Still, in felting pieces of a Crossbred quality, or any class of fabrics which have a disposition to rig, by running in the same set of folds during the process, it is an advantage to treat them in the stocks before felting in the milling machine. This preparatory fulling imparts a condition to the pieces which prevents rig marks, and, at the same time, equalises felting.

(64) *Construction and Working of the Faller Stocks*

Fig. 62 is a section of the ordinary type of fulling stocks, which occupies a floor space of 12 ft. by 4½ ft. Each pair of fallers varies in width from 18 ins. to 28 ins. at the bottom, and are driven by one tappet shaft, suitable foundations A, B, D, F, and H being made and the tappet wheel let partially into the floor as shown.

The tappets, three on each side of the tappet wheel E, raise the fallers which drop by gravity. The approximate speed of the tappet wheel is 13 revolutions per minute imparting 78 strokes of the fallers on the piece at each revolution. The fallers operate on the pieces in the trough T, in two ways. First, they pound the cloth, and second, keep it in constant movement, forcing it against the curved rear portion of the trough.

There are some modifications of this simple mechanism. such as driving the fallers automatically, and the use of three fallers instead of two. In the Grosselin stocks, the two outside fallers alternate in action with the centre faller. The object is to obtain more frequent compression of the pieces and greater felting result. For this purpose, the Russell fulling stocks is also constructed. It may be loaded with pieces at both ends. In the centre is the main driving shaft on which are eccentrics actuating the stock feet alternately from either side, forward and backward. At each end of the stocks there is a trough or box with curved hinged door, against which the pieces are pounded in the felting operation. The capacity of the boxes may be reduced by bringing them nearer to the central shaft.

In the original form of stocks, as pointed out, the fallers are lifted a certain distance, released, and allowed to drop by their own weight. When the action of the fallers is governed by crank or eccentric gearing, the growing force of the impact with the gradually decreasing bulk of the pieces is not a natural sequence as in the faller stocks. By devising means of adjusting the position of the parts operating the fallers, this drawback has been partially obviated. In the stocks sketched in Figs. 63 and 64, there is a contrivance by which the fallers, during shrinkage of the cloth placed in part C, may be automatically brought into closer contact with their work. The position of the shaft B, on which the eccentrics carrying the fallers are fixed, can be advanced a distance of 13 inches. The turning of the wheel A (Fig. 63) by connective gearing alters the shaft from G to F (Fig. 64) and, necessarily, the stock feet E and D, D indicating the position of the fallers when the shaft is at F, and E when the shaft is fixed at G. By this arrangement, the felting of the cloth can be uniformly maintained, and pieces of varying length and weights can be treated.

A second method of automatically controlling the action of the fallers, consists in crank driving, and connecting arms or levers which may be varied in length. In each system, in order to have increasing compression on the pieces throughout the operation of fulling, the fallers are, at intervals, mechanically adjusted, but in the original faller stocks no such adjustment is required.

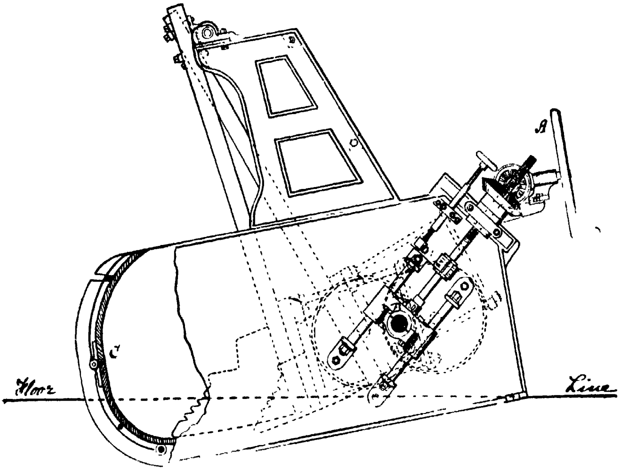


FIG. 63.

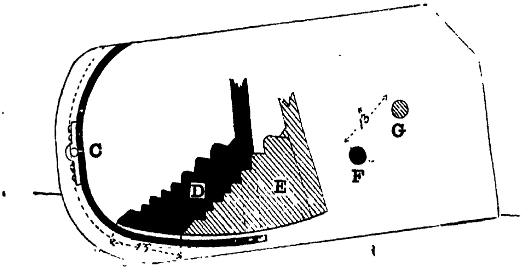


FIG. 64.

(65) *Milling Machines.*

Fig. 65 is an illustration, Fig. 66 a side elevation, and Fig. 67 a front elevation of the ordinary type of milling machine. Fig. 68 is a view of a milling plant.

The machine is 4½ ft. wide, 8¾ ft. long and 7 ft. high, the speed of the shaft being about 80 revolutions per minute. The main parts of the machine, Fig. 67, are the knocking-off motion K,

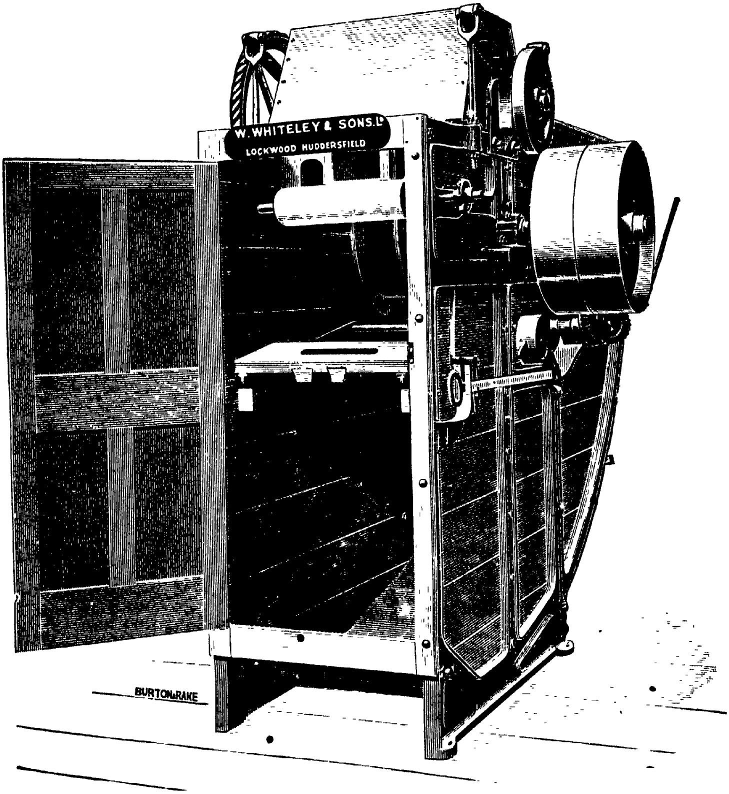


FIG. 65.

R and C, flanged roller, B, pressure roller B^1, the neck or throat N, and the parts for milling in length, shown in Fig. 69. The pieces pass through the divisions in the board K, over the guide roller G, between the rollers B and B^1, through the spout S, Fig. 69, and into the bottom of the machine. Should the pieces for any cause get fast in the machine, the board K rises, and by the connections C, removes the strap from the fast pulley P, on to the loose pulley P^1. As shown, the two rollers B and B^1 are driven by spur wheels, A being on the main or central

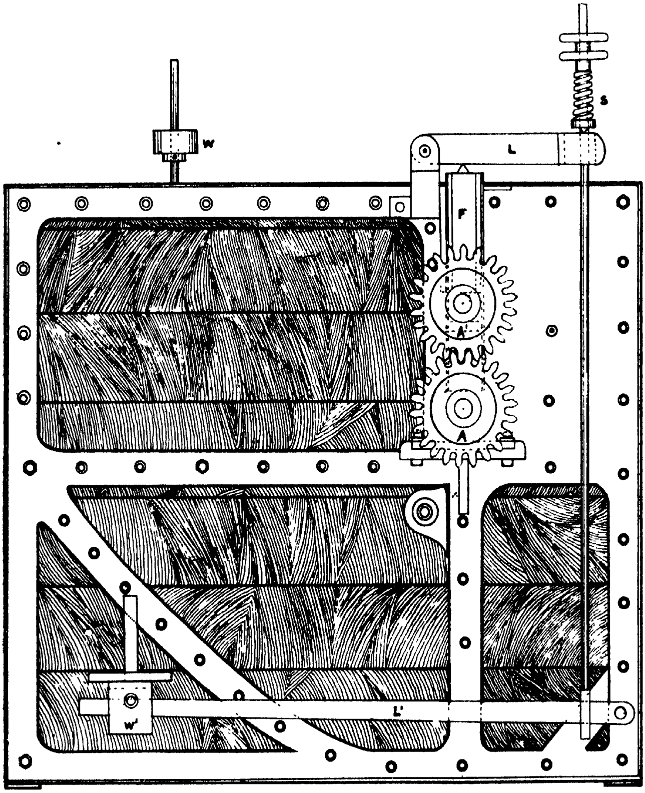


Fig. 66.

driving shaft and gearing with A^1 (Fig. 66). The upper roller B^1 fits within the flanges of B (Fig. 67), and receives pressure from the levers L, L^1 (Fig. 66). This is not the common device for weighting. It has been designed in the Textile Department of the Leeds University for experimental work, and for the

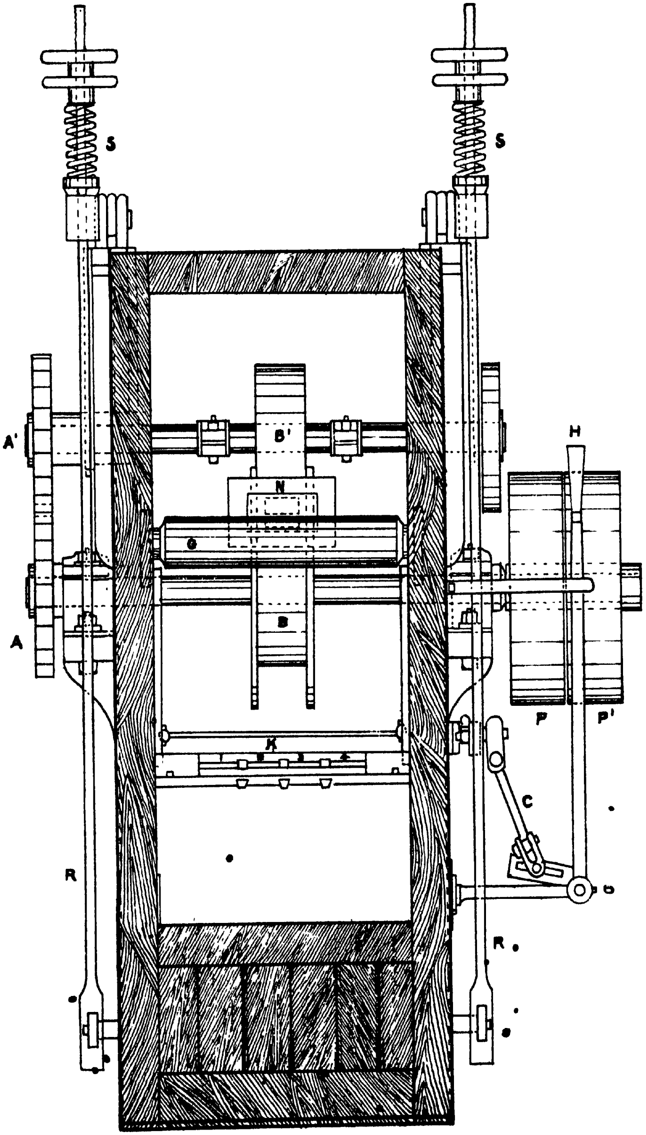


Fig. 67.

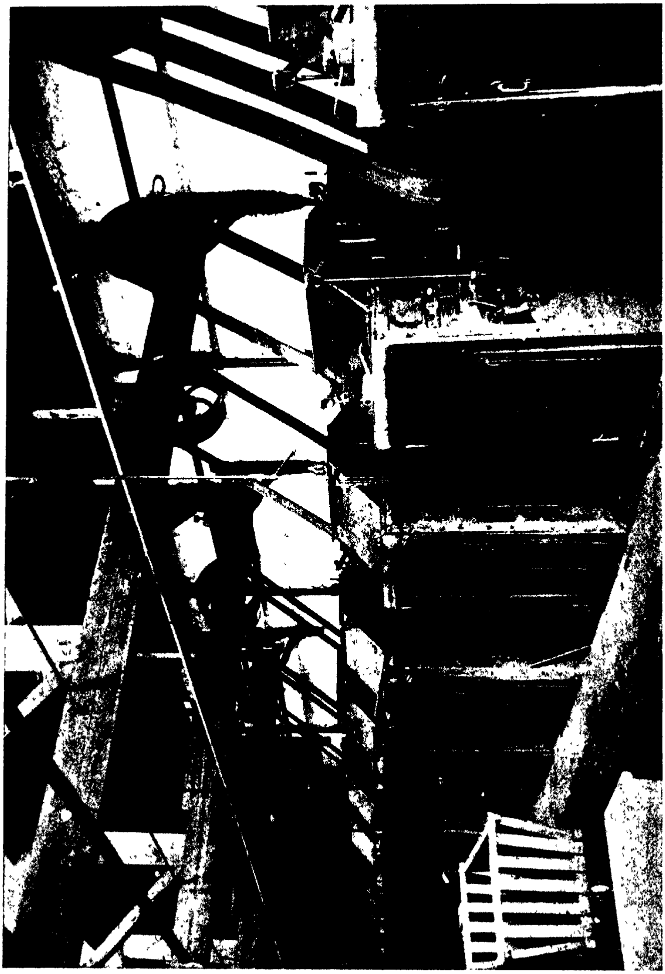


FIG. 68.—Plant of Milling machines.

regulation and registering of the weight transmitted by means of the upper roller on the pieces. Usually, the part F—duplicated at the other side of the machine—fixed on the shaft of wheel A^1, by spring arrangement is made to increase or diminish the pressure on the flanged roller.

In Fig. 69, the arrangement for weighting the lid and retaining the pieces in successive lengths in a cuttled state, is shown. The lever C, secured to D, is on the end of the shaft of roller B^1.

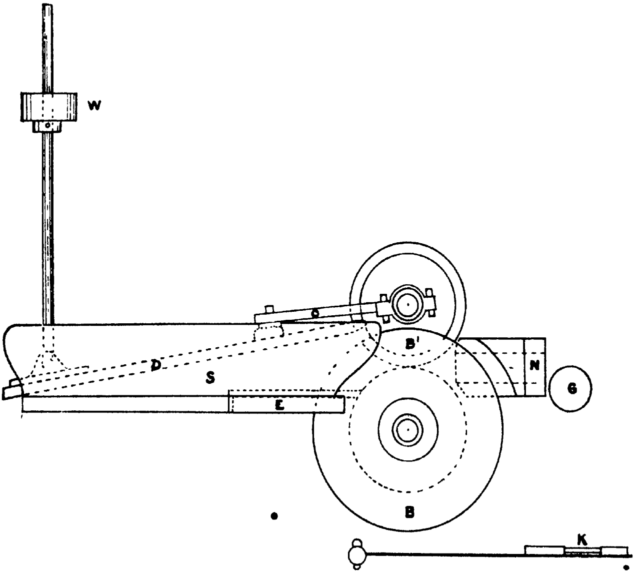


Fig. 69.

Having applied the necessary quantity of soapy solution to the pieces, they are passed through the apertures 1 to 4 in the board K (Fig. 67) over the guide G and into the neck N. Here they run through a diminishing space to the nip of the squeezing rollers, pressure being chiefly on the weft direction of the fabric. They are, in this manner, guided and kept within the flanges of the roller B, the degree of shrinkage depending mechanically upon the resistance of the upper roller B^1.

The weight W (Fig. 69) is increased to give additional

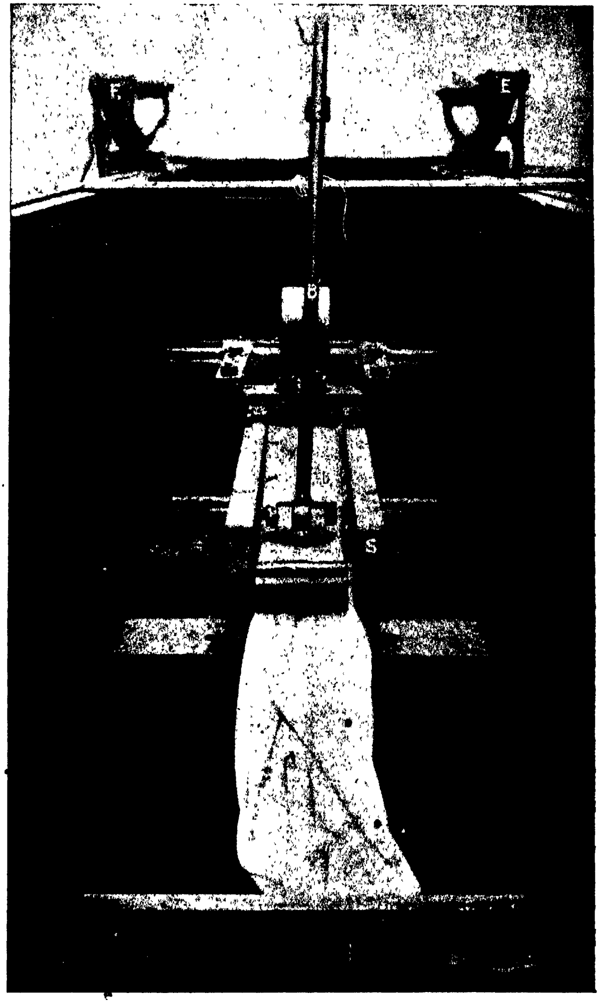


Fig. 70.—Interior of milling machine.
E = springs, B^1 = upper roller, D = lid, S = side of spout.

shrinkage in the length of the pieces, which cuttle in folds when held by the lid D of the spout S, remaining thus until the accumulated length lifts the lid and travels forward to the lower part of the machine. This action is illustrated in the two views

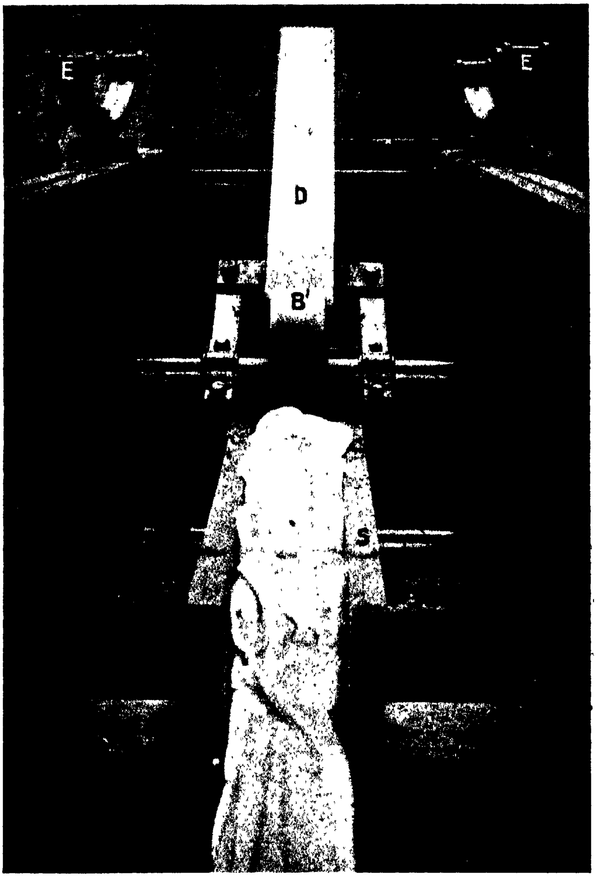


Fig. 71.
E = springs, B' = upper roller, D = lid, S = spout side.

of the interior of the machine given in Figs 70 and 71, the back part, and also the upper portion of the framework having been removed. The former shows the cloth as it passes from the spout under pressure of the lid, and the latter, the cuttling of the cloth in the spout, the lid being turned back for this purpose. It will be seen how on the pieces immediately being released from the squeezing rollers, they fill the spout, cuttling or accumulating in folds. This is conducive to felting on the length, especially when the lid is heavily weighted. In Fig. 70, a length of the cloth has just been forced from the spout, with the lid in normal working position, to repeat the retaining and pressing action on the cloth in process of cuttling in the spout.

(66) *Routine of Milling.*

The passage of the cloth through the machine may be briefly described. The pieces, as seen in Fig. 72, pass through the knocking-off board K, over the guide roller and through the neck into the spout (Figs. 69, 70 and 71). From here they move in a cuttled form down the sloping end of the machine, in which condition a certain amount of shrinkage transpires. This varies with the length and weight of the pieces, these being factors which affect the pressure on the folded condition of the cloth.

It will be observed, that by this routine the pieces are compressed at several stages, and in different ways. First, in running through the spaces in the knocking-off board, next between the horizontal guide rollers, if two are used, and in some machines between vertical guide rollers to be compressed in the neck or throat, followed by similar action between the squeezing rollers, then the shrinkage in length in the spout, and, finally, as the pieces travel into the lower part of the machine. Felting takes place wherever pressure or cuttling is applied, so that there are only the lengths of cloth between the spout and the rear end of the machine, the front of the machine from the bottom to the knocking-off board, and from the latter to the guide rollers, where felting is not actually forced by mechanical action. The frequent repetition of these operations, continued during periods varying with the amount of felting necessary, produce and maintain felting conditions.

(67) *Corrugated Guide Rollers.*

When the pieces are run in drafts, say four together, each piece enters a separate aperture in board K, Fig. 67. The two outside pieces, when they run direct to the neck over a simple guide roller, travel at a different angle from the pieces in spaces 2 and 3. This may produce ballooning and knotting of the pieces. In Whiteley's machine, a pair of corrugated guide

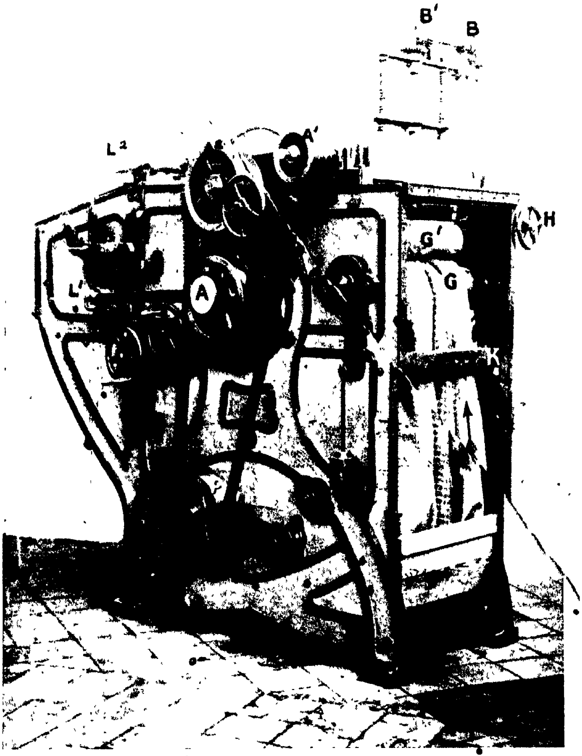


FIG. 72.—Hemmer's milling machine.

rollers G and G^1 (Fig. 73) are useful in removing this defect, and also in acquiring some additional shrinkage on the cloth for each round through the machine. The construction of the machine, and the relation of the parts to each other, are seen in the side elevation (Fig. 74). Passing through the knocking-off

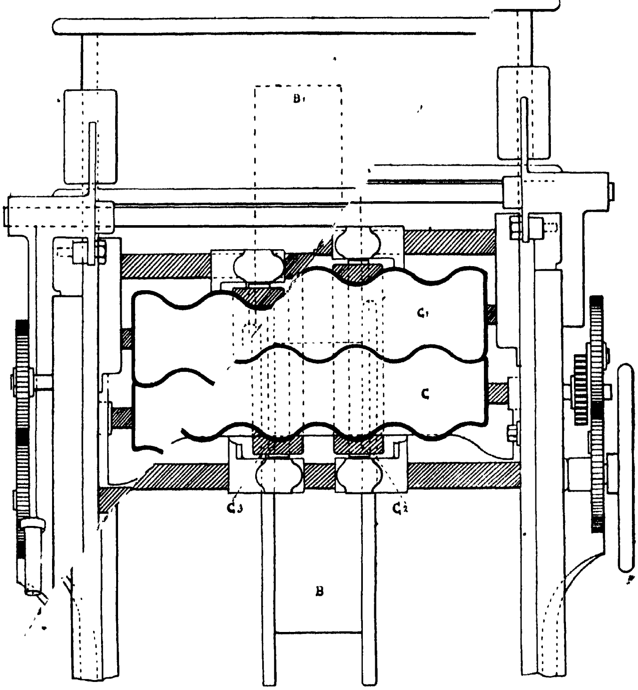


Fig. 73.

board, the pieces are taken between rollers G and G^1 to a pair of vertical rollers, and then follow the usual routine. There are, thus, two methods of crushing and also of changing the folds of the pieces before they reach the flanged roller, namely, horizontal crush between G and G^1, and crush by the vertical rollers G^2 and G^3. The rollers G, G^1, and G^2, G^3, are adjustable to take pieces of various weights and to modify the felting pressure. This compound roller crushing on the pieces is effective both as a factor in milling and in preventing rig marks.

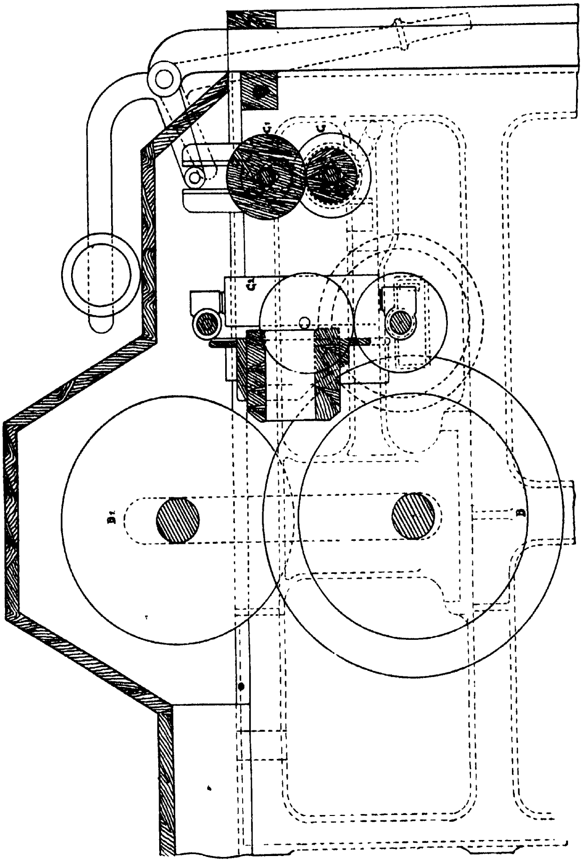


Fig. 74.

(68) *Machines with Two or More Upper Rollers.*

Several English and Continental makers of milling machines have adopted the plan of placing two or three rollers over the main squeezing roller, with the object of more frequently crushing the pieces than if only one roller were used. A common and simple method of driving such rollers is by spur-wheel gearing, but in the Hemmer and Kemmerich machines

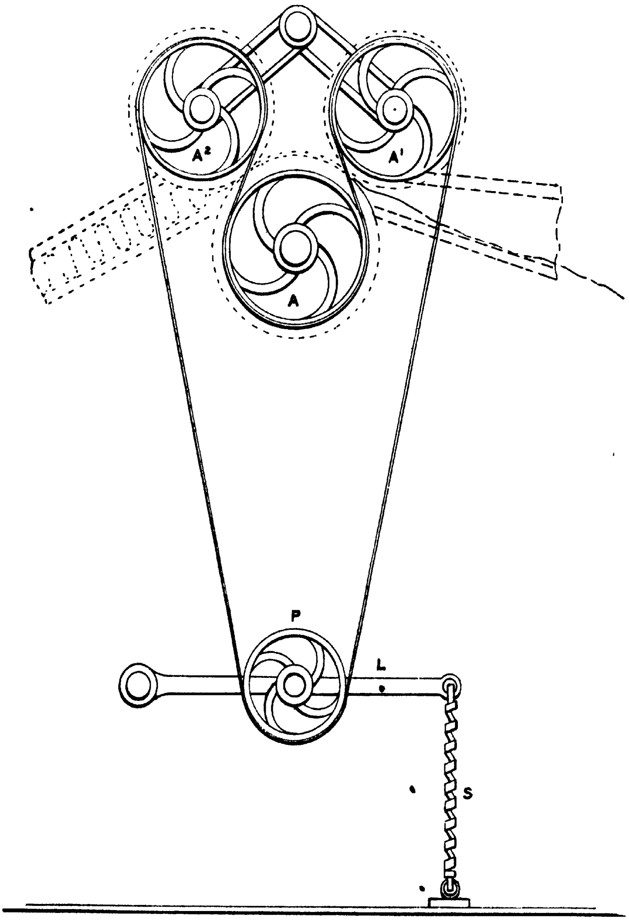


FIG. 75.

other devices are applied, namely, those sketched in Figs. 75 and 76. In both, the idea is to obtain a positive uniform drive, and yet one of some give or elasticity in the relation of the upper rollers to the surface of the lower roller. With the use of spur wheels, such rollers may only be lifted by the cloth to the extent of keeping the wheels in gear with each other. Both rollers are

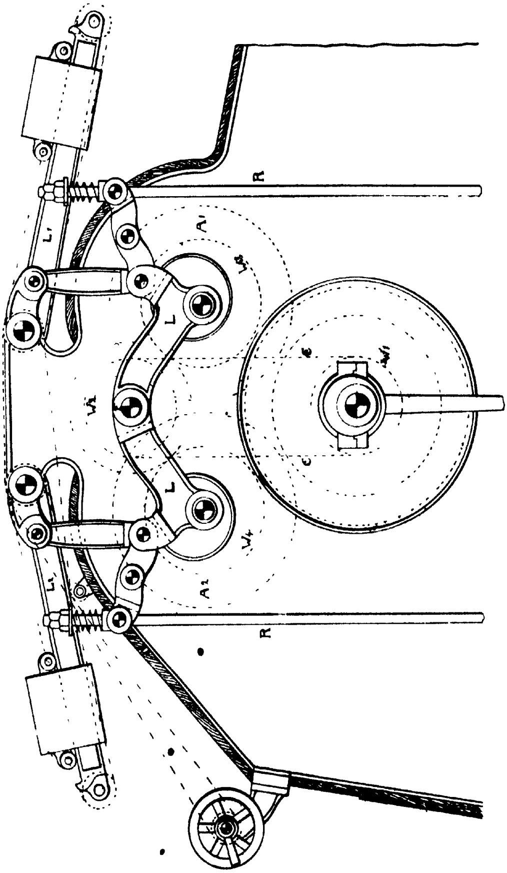


Fig. 76.

under pressure due to weights or springs. In the two drives (Figs. 75 and 76) there is, possibly, more elasticity of vertical displacement of rollers B and B¹ (Fig. 69) with a constant and uniform speed. As seen in Fig. 75, the pressure is applied to rollers A^1 and A^2 by the driving strap passing first round the pulley A on the central shaft, over the two upper pulleys, and under the pulley P on lever L weighted or tensioned by spring. This method of driving is also shown in the view of the Hemmer machine (Fig. 72).

In Fig. 76, the pressure rollers are carried on levers L fulcrumed at F. This lever is connected by links to weight levers L^1 and L^2. (The connecting rods R, R^1 communicate with the mechanism for putting the machine out of action.) The positive drive is obtained by chain gearing. The chain C passes round W^1 on the main shaft, and W^2 on the shaft of the carrying lever L. Connection wheel drive is direct from this shaft, with wheels W^3 and W^4 on the shafts of rollers A^1 and A^2. The distance of the pressure rollers from the bottom roller can be mechanically adjusted, and the former may, also, change angularly in relation to the fulcrum F of lever L.

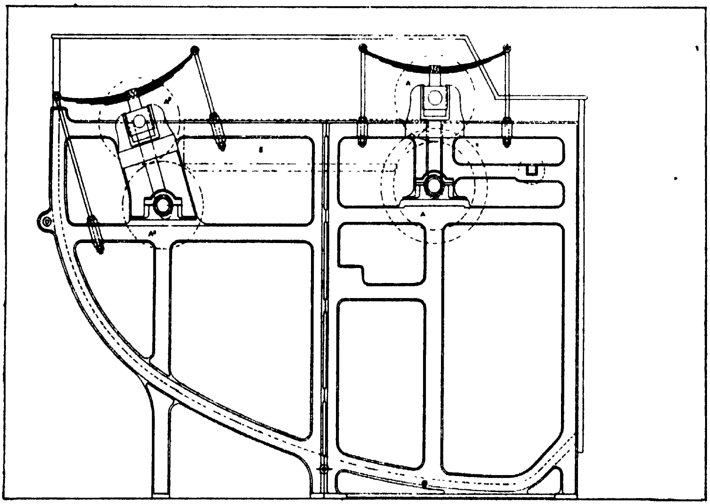


FIG. 77.—Whiteley's Duplex Milling Machine.

(69) *Duplex Machines.*

Two types of duplex machines, very different in construction, are sketched in Fig. 77 and Fig. 78. In Whiteley's machine (Fig. 77) there are two pairs of rollers, the first pair A, A^1, bearing the same relation to the guide rollers, neck and spout, as in the ordinary milling machine. The supplementary rollers A^2, A^3 are placed at the rear of the spout. Both pairs of rollers are under spring control. Milling is the same as in the ordinary machine until rollers A^2, A^3 are reached. These rollers are eighteen or more inches from end to end, to allow lateral spreading or opening out of the pieces. On leaving the spout, the pieces, before passing into the lower part of the machine, are subjected to horizontal crush or pressure, varied by the degree of felting required on the weft.

This additional feature of the machine has two effects: roller action after cuttling warp ways in the spout, and supplementary felting weft ways. There is, first, shrinkage due to passing through the neck, and over the flanged roller, both of which are on the weft, as explained; second, felting on the warp; and third, felting on the weft.

The milling action is also varied in character and amount, in the class of machine sketched in Fig. 78. By following the routine of the cloth, the nature of the compound felting which is produced will be understood. There are two pairs of main squeezing rollers, with supplementary horizontal and vertical rollers, as well as the usual felting in the spout. From roller G, the pieces are compressed by vertical rollers B, and enter the neck N of the machine, pass forward to the squeezing rollers A, A^1, and A^2, A^3, which are ordinary rollers without flanges, and some eighteen inches wide. From the first pair, A, A^1, the pieces run between the vertical rollers B^1 (only the rear one shown) to the second pair of horizontal rollers A^2, A^3, and into the spout S.

There are several mechanical compressions at various stages in the milling routine. First, between vertical rollers, the cloth being made to spread within certain limits vertically, under transverse pressure; second, in the neck, where the pressure is on both warp and weft of the pieces; third, between the first pair of squeezing rollers; fourth, between the second pair of vertical rollers; fifth, repetition of the third process between rollers A^2 and A^3; sixth, chief shrinkage in the spout on the warp way of the cloth.

In the Hemmer machine, the pairs of squeezing rollers may be run at the same or different speeds. This allows, first, of the pieces being tensioned in length during milling; and second, of an auxiliary felting by the accumulation of the cloth on a board fixed between the two pairs of rollers. Over the board there is a tongue, so that a certain amount of pressure may be applied as the cloth passes to the second pair of rollers.

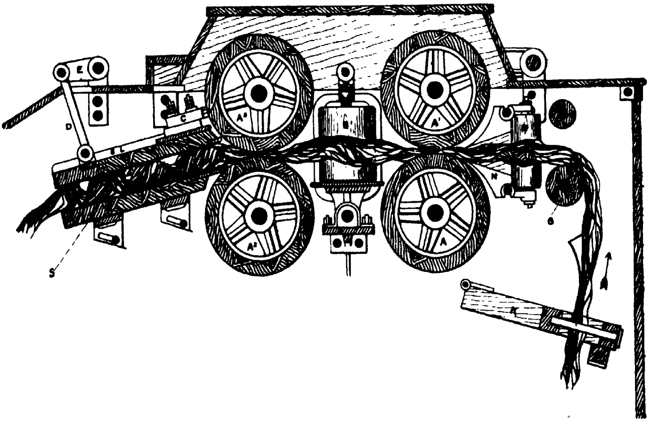


FIG. 78.—Duplex milling machine.

Tensioning of the pieces between the rollers may be satisfactorily done when little milling is required on the warp, as, for example, in treating pieces made with worsted warp and woollen weft, and in which the object is to retain, as near as possible, the scoured length, effecting the shrinkage in the width.

In these duplex machines, diversity of felting action is provided. This must increase the amount of felting possible in a given time, and be more economical in results than the single type of machine. But there are other advantages, namely, more even milling, and less liability to produce rig marks and faults. With the diversity of roller action, there must be frequent changing in the relative positions of the layers of fabric. The pieces may, in this way, be run and milled continuously in length, with little possibility of defects arising in the cloth.

(70) *Machines without Flanged Roller.*

The use of a flanged roller with one or more upper rollers fitting between the flanges, is a sound principle of construction in milling machines. One advantage is that the pieces are forcibly held within the width of the flanges when under heavy vertical pressure. This secures rapid felting, but may also be the cause of faulty work. If there is not sufficient weight on roller B^1 (Fig. 67) the pieces are liable to get over the edges of the flanges, or should the lid, in consequence of the weight applied, be too operative, the spout becomes overloaded. Such defects can, as a rule, be obviated by proper regulation of the weight and length of cloth put in the machine, and of the pressure on the squeezing rollers and the lid of the spout.

Several other forms of rollers are also used in milling machines, such as corrugated, concave and convex, and plain surfaced. In the machine described (Fig. 78) the squeezing rollers are plain, but wide enough to prevent the pieces spreading over the ends, when passing between the rollers. The vertical guide rollers in front of the squeezing rollers in this type of machine, have the effect of maintaining the pieces in a compressed and central position.

In the Hemmer tandem machine, rollers of different construction are used for the front and back pair. The first pair may be corrugated circumferentially, and the second pair transversely to the circumference, the recesses of the lower roller in each pair being opposite the raised portions in the upper roller. Neither of these systems of milling gives that lateral or side pressure which is such an important feature when the pieces are held within a pair of flanges and subjected to vertical pressure.

(71). *Mechanical Devices applied to the Spout.*

The spout is an essential part of all milling machines for acquiring felting in length. Ordinarily, the spout lid is weighted.

In some machines, *e.g.* Kilburn's, the sides may also be made to oscillate, and a hinged portion of the lid may operate upon the cloth vertically. In neither of these modifications is there any change in the form of, or additions to, the spout.

Increased felting is made possible by two devices; first, the introduction of a series of rollers into the spout; and second, of pounding or hammering mechanism. The object of both is to add to the felting capacity of the machine, and also to change the condition of the layers of cloth formed between the squeezing rollers.

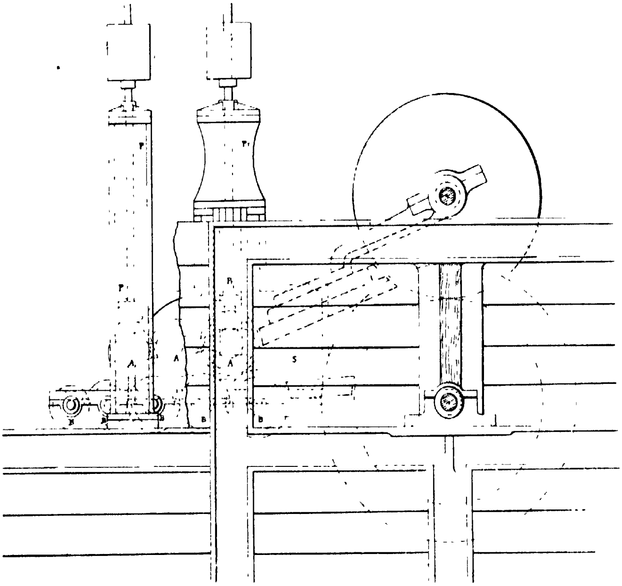


Fig. 79.

Kilburn's improvement (Fig. 79) consists of two series of rollers, the lower five, and the upper series three in number. These are placed at the rear end of the spout, and form a supplementary part of it. The three upper rollers are linked together and mounted on the uprights P, P^1, which are weighted, so that the felting action imparted to the cloth is adjustable.

In the milling of heavy cloths this arrangement has been found satisfactory. In Preston's machine, a large corrugated roller is fixed below the end of the spout, and three smaller rollers, also corrugated, arranged triangularly over this roller. These retard the progress of the cloth, holding it, for a period, cuttled in the spout. The pressure of the rollers on the pieces, and their retarding and milling action, can be modified by lever and crank gearing.

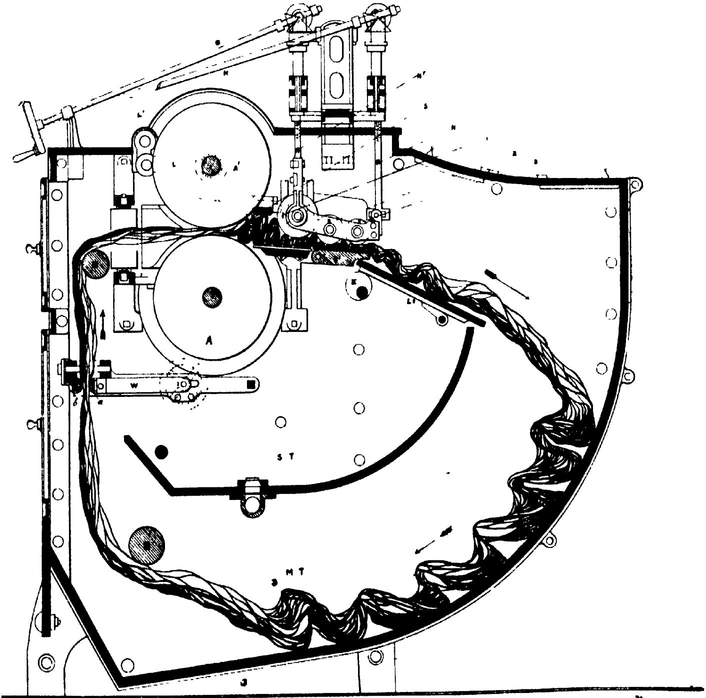


FIG. 80.—Crosset and Debatisse milling machine.

Another machine (Figs. 80 and 81) in which rollers are fixed in a frame and operated in the spout, is constructed by Crosset and Debatisse. Such rollers, with the method of regulation of the pressure on the fabric, form two of the principal features of the machine, but there are other important mechanical details.

In the first place, the adjustment of the upper squeezing roller, and that of the rollers in the spout, may be done from the front of the machine by wheel and handle. The method of driving the top roller A¹ is also different from that of other

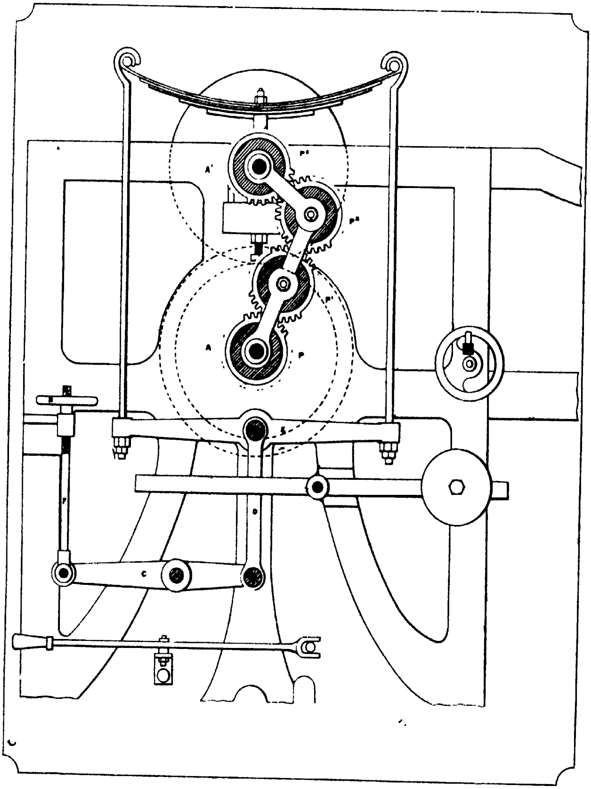


Fig. 81.

machines. On the shaft of roller A (Fig. 81) there is a toothed wheel P, which, through two intermediate pinions P¹, P², drives the toothed wheel P³ on the end of the upper roller A¹. The point of gear of this wheel with the upper pinion may be varied.

The shaft of the upper roller A^1 is carried by levers L and L^1 (Fig. 80). The raising or lowering of the roller is done by turning the handle B (Fig. 81) fixed on the shaft F, which through levers and connections C, D and E, may increase or lessen the pressure on the upper roller, by the action of the springs at either side of the machine.

A second feature is the upper trough, ST (Fig. 80) which may be used for soaping or scouring. Assuming that it is used for soaping prior to milling, that is, to get the pieces evenly saturated, by turning the shaft on which the eccentric E is fixed, the board L^3 is lowered, and the hinged portion of the spout S^1 falls below the eccentric, so that the pieces instead of running, as seen, over the slide L^3, may pass direct into the upper trough ST.

But the chief characteristics of the machine are the rollers 1, 2, 3, and their action in the spout. These are fastened together by cross-bars, and suspended on the uprights N, N^1, at the top of which are carried bevel wheels gearing with the wheels on shafts H and G. The distance of the rollers from the base of the spout S, can be adjusted by the handle, through the thread portion of the uprights N, N^1. As the regulators for N, N^1 are independent, roller 3 may be brought nearer to the bottom of the spout than roller 1, and the resistance offered to the piece increased. The roller action has a certain changing effect on the piece, which is not present in the use of an ordinary spout lid, and also adds to the fulling process.

The routine of the cloth is indicated by the arrows. The pieces pass through the wringer or knocking-off board W, of which parts *a* and *b* are adjustable, so that the space may be altered with the thickness of the cloth to be milled. There are several sections in the wringer. The pieces then pass over the guide roller, and through the throat and squeezing rollers to the spout S, where they are subjected to the roller fulling, with the hinged part of the spout S^1 fixed as shown, over the guide board L^3 and into the lower trough MT.

(72) *Roller Milling Machine with Stampers in the Spout.*

The improvements which have been described as additional to the action of the spout have, for a primary object, the turning over of the pieces for the prevention of defects, as well as to produce increased felting. The two systems in Figs. 82, 83

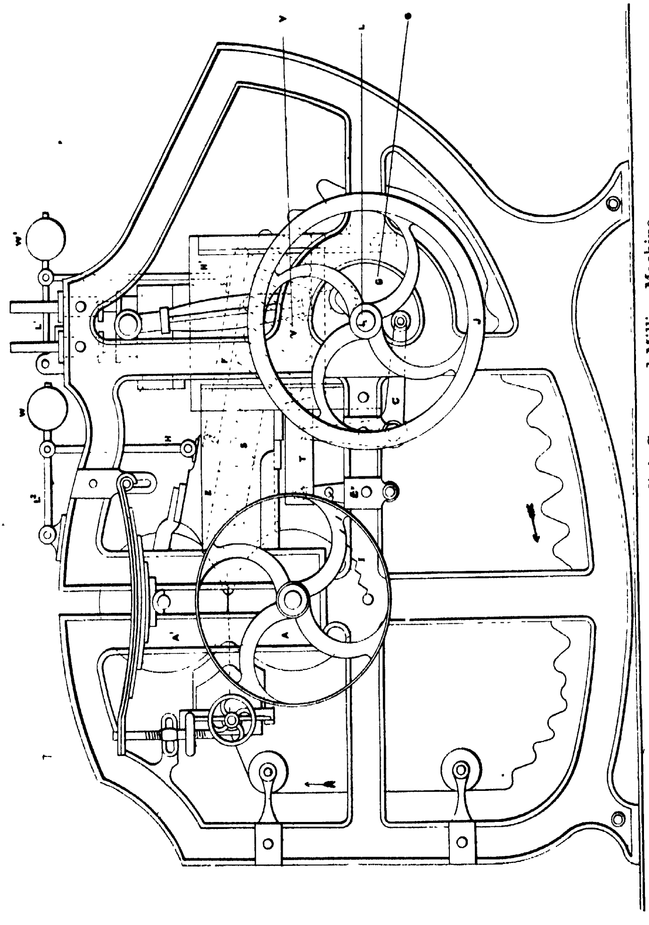


FIG. 82.—Grosselin's Compound Milling Machine.

and 84 show methods approaching, in principle, the action of the faller stocks. There is, in addition to the milling, which is performed in the centre parts of the machine, a pounding or beating of the cloth, whilst in cuttled form, in a portion of the

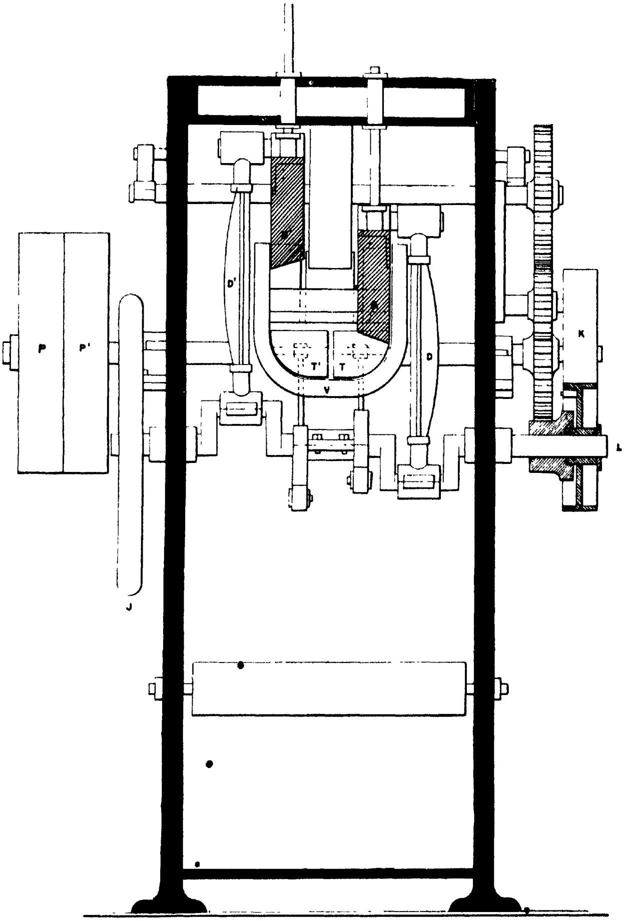


FIG. 83.—Grosselin's Compound Milling Machine.

spout. There can be no doubt as to the increased fulling result effected by this form of mechanism. It will be seen later, how, as a further development of this idea, milling machines are also made, in which automatic fallers operate on the cloth after it leaves the spout, during accumulation in a receiver.

Taking the Grosselin machine (Figs. 82 and 83) the primary improvement is the use of vertical beaters, which are actuated by crank shaft L and arm connections D, D^1. Fig. 82 is an end elevation of the machine, and Fig. 83 a front elevation. The machine is driven in the usual way. The pulleys P and P^1 are on the main shaft of the flanged roller, on the opposite end of which is the pulley K, which by belt drives the pulley on the crank shaft L. This, by clutch gearing, imparts motion to the crank shaft and the beaters. This method of driving makes it feasible to stop the feed rollers, as in the ordinary machine, when the pieces being milled become knotted, and for the crank shaft and beaters to continue for a short time in motion, owing to the impetus of the fly wheel J.

In one construction the piece is pushed forward, on being liberated by the delivery rollers, by propellers T, T^1, into the receiver V. These propellers are actuated by cam G on the crank shaft L, by levers C, C^1, the retarding movement being effected by springs I. The lid, F, of the spout (Fig. 82), is a retaining lever or plate, resisting the forward progress of the cloth. This part F is connected by rod R^1 to weighted lever W^1. Section E, which retains the fabric in the spout S, is fulcrumed on the upper shaft in the same way as the spout lid, and is weighted through connecting rod H and the levers L^1 and L^2.

The operation of the beaters B, B^1 (Fig. 83) is direct from the crank shaft L, beater B being shown in the bottom position, and beater B^1 in the top position, and the propellers T^1 in the forward, and T in the backward position. Necessarily, the propellers must be timed with the beaters, that is to say, moved forward when the beaters come into the position B. The beaters are shaped at the bottom as shown, which has the effect of pressing the cloth inwards, or from one beater to the other, as it is operated upon in the receiver V.

The process of milling is the same here as far as section S, or the miniature spout. It is in the portion V where the compound action of the beaters and propellers takes place. The beaters rise and fall alternately, pressing the cloth laterally from the sides of V to the centre. At the same time, the propellers force the cloth against the pressure lid F, which retains it in the receiver V, by the weights on levers L^1 and L^2.

The machine is well designed and automatic in action; the beaters and propellers coming in contact with the cloth alternately, the beaters hammering or beating the cloth, and the propellers pushing it, by cam movement, forward. In this way the felting action of the milling machine is done between the flanged and upper rollers, and also in the cuttling in the spout, with the supplementary felting or fulling performed by the beaters and propellers, whilst the cloth is retained in the receiver V.

The chief features in the McLardie machine (Fig. 84) are, the method of operating the beaters or plungers, and their position in the spout. In the Grosselin apparatus they are placed at the end of the spout, but here immediately behind the squeezing rollers, and act upon the pieces as they are liberated by the latter. The cloth during cuttling is pounded vertically. This has not only a fulling effect, but also causes the pieces to be constantly changing positions as they pass through the spout.

Fig. 84 is an end elevation of a two-faller machine, but three or more sections may be used, increasing the fulling output, The beaters B, B^1, are driven positively by the crank shaft A, A^1, to which they are connected by arms D, D^1. These are regulated as to the pressure they apply to the cloth, by springs. Each plunger B is corrugated underneath, and also the spout base, in the part where they operate on the fabric. Attached to each beater is a hinged lid, which is weighted, and retains the cloth in the spout. The cloth having been under the roller pressure, collects on section C, and is fulled by the plungers B, B^1, rising and falling alternately, and running in slides S, S^1 fixed to the sides of the machine. It is then felted by the pressure of the spout lid whilst still in a cuttled form.

The method of driving B and B^1 is direct and positive. The driving of the rollers by speed pulleys P^2 and P^3 provides a means of running the squeezing rollers at different speeds to suit the qualities of fabrics being treated. P, P^1 are the loose and fast

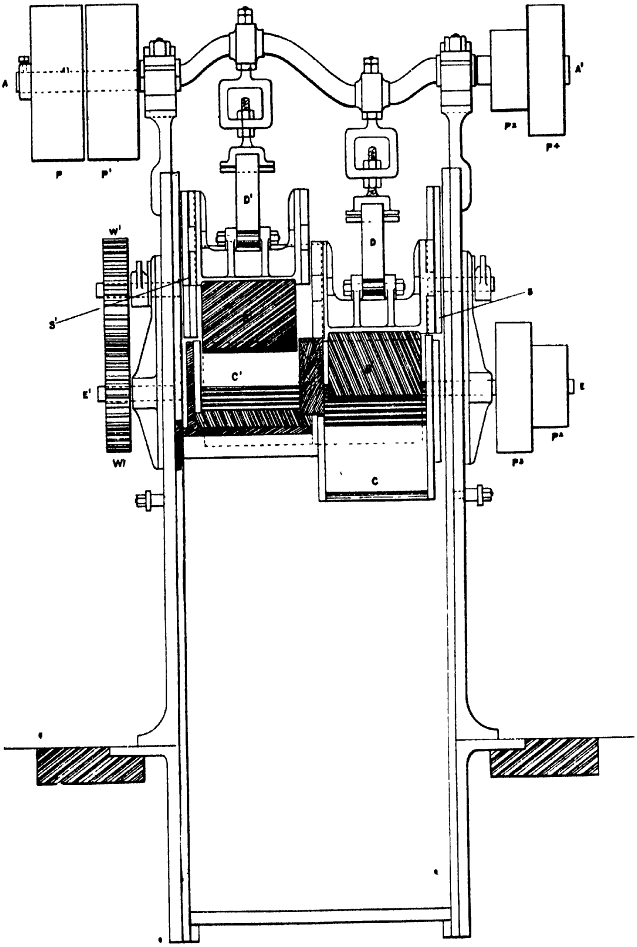


FIG. 84.—McLardie's Compound Milling Machine.

belt pulleys. At A^1 are fixed pulleys P^2 and P^4, which drive P^3 and P^5 on the end of the flanged roller shaft; spur wheels W, W^1 turn the upper squeezing roller of the machine.

(73) *Principle of Combined Milling Machine and Stocks.*

The practice is well understood of using the stocks and milling machine in combination, milling partially in the former and completing in the latter. The utility of this has been shown, but the acquirement of both principles of felting in one machine is comparatively new. In a sense, milling machinery in which vertical stampers or hammers are used is a step towards this construction, for the common form of milling machine is adopted with the additional pounding mechanism. The advantage of combining the roller or cylinder machine and stocks is obvious from the distinctive character of each system of felting. The older system is slow, but even in result; the newer system economical, and rendered more accurate and effective by the improvements referred to.

In the duplex milling machines, though transverse and vertical roller pressure is applied with subsequent cuttling of the pieces, yet there is no substitute for the pounding action characteristic of the stocks. The "cover" of the fulled cloth, due to treatment in the stocks, is of a different quality to that obtained by compression in the milling machine.

There is a difficulty in combining the two systems in the same machine, because the pieces in the milling machine and in the stocks are treated in different conditions; in one they are running continuously, and in the other they are rolled in the ball form. To acquire a similar action in the milling machine as in the stocks, necessitates that in some part of the machine there should be a confined space, in which a sufficient length of cloth may be compacted and worked upon by fallers. At the same time, the continuous passage of the cloth between the rollers is an essential: in other words, there must be intermittent felting, or rather fulling of successive and corresponding lengths of the piece by the stocks, and continuous action on the pieces between the squeezing rollers. Several lengths of cloth must collect in the space in which the fallers operate, be subjected to their action for a short time, and then released, other lengths of cloth following successively. To do this a new type

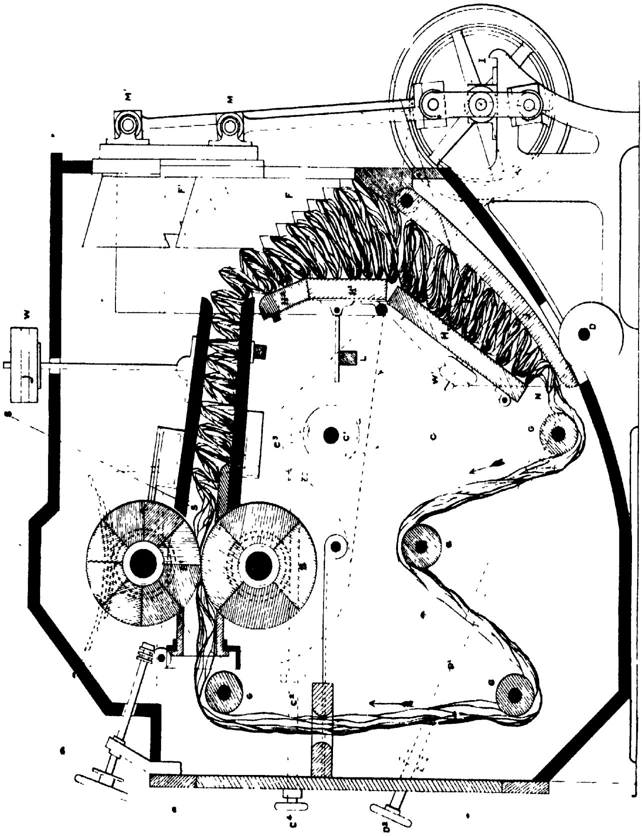


FIG. 85.—Preston's Combined Milling Machine and Stocks.

of machine, with the essentials of an ordinary milling machine, is necessary.

Preston's machine, sketched in Fig. 85, comprises the ordinary milling parts with vertical fallers. One of the principal features is the receiver K, with adjustable lower portion J, and upper or side portions H, H^1, H^2. In the stocks, the pieces are constantly being turned over, which secures even felting, but this is not possible when the pieces are subjected to roller and faller action alternately. In this case, though it is necessary that the pieces should be held in the space K under faller action, F, F^1, still the mechanical parts limiting this space should not be absolutely rigid. During the running of the machine, this section K must be filled by intermittent feeding from the spout S, maintaining a constant supply of cloth. The fallers, operating upon the cuttled pieces, press them closer and closer together as they pass towards point N. When the layers of fabric are so compactly forced together that the faller action has no further compressing effect, part H rises, lifting the weights W^1, and a length of cloth escapes. This fulling intermittently, in the receiver K, cuttling and forcing the layers of fabrics into more compact relation, continues throughout the milling operation.

The regulation of these parts is done mechanically. The hinged section H is adjusted by chain C, chain wheel C^1 and the shaft C^2, the worm wheel C^3 which gears into the wheel C^1. The less the weight and thickness of the cloth, the less the distance of H from J at point N. J is adjusted by shaft D^1, carrying a worm wheel gearing into the tappet wheel D, so that by turning this at D^2, the movable part J may be highered or lowered. H is similarly altered by turning C^4, closing or opening the space through which the pieces pass into the bottom of the machine. H^2 is also adjustable, having a cross shaft, through the divisions of which locking pins may pass into part L.

The driving of the fallers is done by crank shaft on wheel I, turned by strap from the pulley on the shaft of roller B. Through the upright arms M, M^1, alternate movement is given to the fallers F, F^1. The routine of the pieces in the running of the machine is seen from the arrows, G being guide rollers.

For the felting of heavy cloths, such as Irish friezes, and where the process is required to be rapid, this duplex milling is effective. The combination of the roller milling with that of the stocks, also frequently changes the relation of the lengths of fabric, and in this way proves a preventative to rig marks, producing, at the same time, good fulling quality in the cloth.

(74) *Milling Apparatus Applied to the Scourer.*

In scouring machines, certain modifications are applied which induce some felting. For fabrics in which only light milling is necessary, such as costumes and tweeds, various forms of combined machines are used.

Kilburn's machine has already been referred to, but it is more of the character of a milling machine than of a scourer to which special apparatus of a simple construction has been applied, to obtain a degree of milling.

The invention of Bailey (Fig. 86) consists in removing the draft board from the scourer, and substituting in its place a number of guides or necks N, similar to the throat in the milling machine. This results in squeezing the pieces in the folded condition each time they pass through the machine, in addition to the pressure applied between the main scouring rollers. Cross-drafting of the pieces may be practised as in the "scourer".

There is an advantage in this method, in dealing with fabrics of the light Cheviot type where bright colours are used, as in one and the same operation the pieces are scoured and felted to a sufficient degree. One process is thereby saved, and this should leave the fabrics with a cleaner tone, than if they were, in the first place, scoured and washed-off, and subsequently milled and rewashed-off.

(75) *Milling without Artificial Compression.*

In the several methods of felting described, mechanical pressure on the cloth has been an essential feature. If it is feasible to mill without such compression, pounding or hammering and friction, the fabric would suffer to a minimum degree.

in the waste of fibre or flock. A measure of fulling is, no doubt, possible, in woollen and worsted fabrics, when saturated with soapy solution, by simply running between squeezing rollers, and retaining, behind such rollers, lengths of the cloth in cuttles or folds. But this is not the milling characteristic obtained in heavy cloths in faller stocks or the milling machine. There are some varieties of fabrics manufactured in which light milling or shrinkage is only necessary, and which, during milling, it is an advantage to run full width. Worsted serges, and worsted warp and woollen weft Vicunas, and other classes of worsted fabrics in which some milling improves the finished result, should be treated by this method.

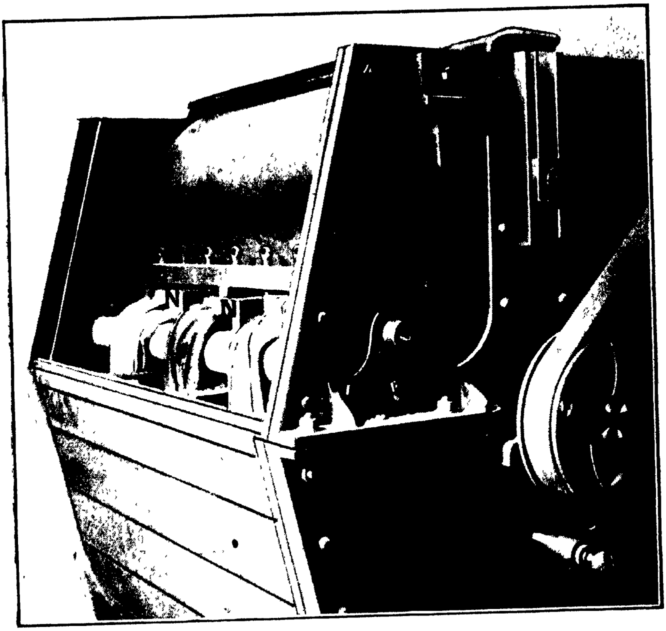


FIG. 86.

The machine (Fig. 87) of Tinker and Arran, is for the combined purpose of scouring, milling and crabbing. It consists of the main trough T, shaped as in a milling machine, of the upper trough T^1 used as in scouring, and washing-off, of the squeezing rollers B, B^1, and of perforated rollers for blowing the piece with steam. The fabrics may be run full width, or in the rope condition, in which case they are treated as in scouring, with the usual draft board. Perhaps the chief utility of the machine is in the felting of pieces full width, when they pass over guide

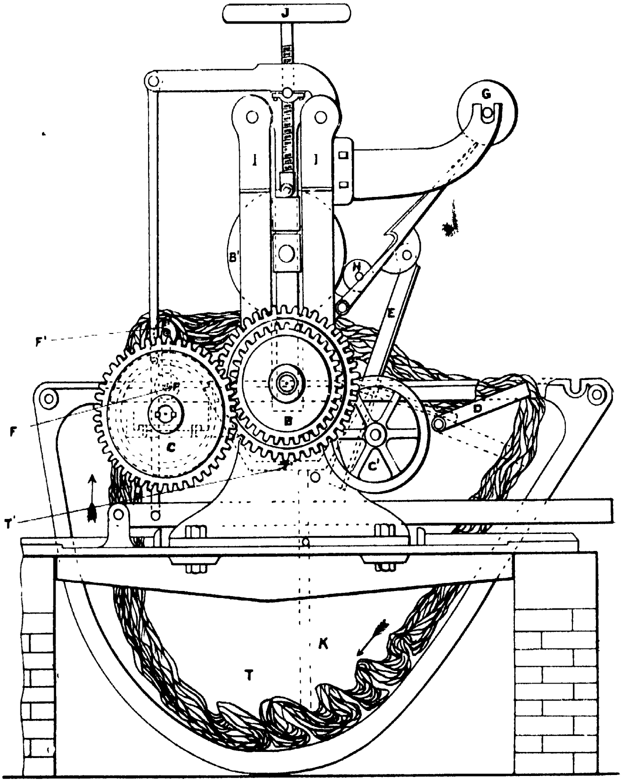


Fig. 87.

roller F^1 from the bottom of the trough T, between rollers B, B^1, and cuttle on the board D. The shrinkage is regulated by the angle at which this board is fixed, and the amount of cloth which is retained in a folded state from the nip of the rollers B, B^1, to the end of the board D. (In the drawing, a part of the frame-work has been removed to show the effect of raising D, and the cuttling of the pieces). A supplementary fulling board K, may be further made to retain the pieces passing from D down the sloping frame-work to the bottom of T. When scouring, the hinged board D is lowered, and the pieces pass from B, B^1, into the lower part of the machine, thence to guide rollers F^1, the pressure on B being adjusted by wheel J. After scouring, one method consists in running the pieces on to the perforated roller and blowing with steam, rewinding on to a second roller from the opposite end, and reblowing, which has the effect of fixing, setting and levelling the fabric prior to milling. Milling, however, may be the only process in some classes of finish after scouring; but in worsteds and Crossbred-yarn fabrics, it is desirable to crab or blow before milling.

CHAPTER VIII.

THE THEORY OF RAISING.

(76) Treatment of the Cloth. (77) Condition of the Cloth. (78) Dry Raising. (79) Damp and Wet Raising. (80) Raising Determined by the Degree of Felting. (81) Quality of the Material and the Raised Result. (82) Raising and Weave Structure. (83) Quality of the Fibre and Yarn Structure. (84) Raising of Fabrics in which Special or Fancy Yarns are used.

(76) *Treatment of the Cloth.*

RAISING has already been defined, and its action on the cloth explained. It is understood how, in this process, an otherwise thready surface is, by degrees, covered with fibre, termed the pile of the cloth. In some raised fabrics, this pile resembles that obtained in weaving: but, whereas in weaving, the pile is the result of cutting floats of either warp or weft yarns, causing the ends of the threads thus produced to project vertically from the foundation of the texture; in raising, the pile is the result of combing the extraneous fibre on to the surface of the cloth. In the manufacture of certain classes of rugs, the pile developed by raising is similar in character to that due to the operation of weaving, but it has not the same permanent effect.

The method of treating the cloth varies in routine, and also according to its condition of moisture. Raising as shown (Pars. 25 and 26) may be on the warp, weft, or both warp and weft, and the piece may be dry, damp, or wet.

The objects of raising are, by the action of the points of the teazles or card-wire, to disturb, raise up, and straighten the fibres on the surface of the fabric; and second, to produce a definite character of pile, such as the rough pile in the melton, the velvet pile in rugs, and the smooth dress-face pile in doeskins and beavers. The action of the raising points in relation to the surface of the cloth may be:—

(1) The raising points may move in the opposite direction and have a higher superficial speed than the cloth, as in the Raising Gig (Fig. 118).

(2) In card-raising machines, the card-covered rollers and the points of the clothing may be in the same direction as the cloth, with the rollers having a higher superficial speed than the latter.

(3) The cloth may be acted upon in two ways alternately; *e.g.*, both series of rollers may travel against the cloth, but the points of the card-clothing act upon the piece in one series, and the back of the card-wire in the other series of rollers.

In the first of these methods (Gig machine), the raising points resist the forward movement of the piece, combing and straightening the fibres; in the second, they draft through the fibres; and in the third, there is compound action, both methods of raising taking place in succession.

(77) *Condition of the Cloth.*

In the process of raising, the condition of the cloth as to moisture has an important effect upon the fulness and quality of the pile of fibres. This is the case in different classes of material, *e.g.*, short, medium, and long-stapled wools, mohair, alpaca, and camel's hair. In a fabric raised dry, the pile of fibres is comparatively rough, and may be readily removed in cutting; if damp, the fibres are laid in one direction, and do not form what is termed a "velvet" or vertical pile. Certain makes of fabrics, as that illustrated in Fig. 89, in the manufacture of which a more or less lustrous material is used, raising *wet* gives a wavy, undulated appearance; should the same fabric be raised *dry*, no waviness would result, but a loose, rough shag of fibres. Each condition—*dry*, *moist* or *damp*, and *wet*—has a specific effect and requires to be considered separately.

(78) *Dry Raising.*

Dry raising lifts or gets up the fibre on to the surface of the texture, so that in the cutting operation the weave and pattern due to colour may be clearly brought out. Several classes of costume and suiting cloths in Cheviot, Saxony and Crossbred yarns are treated in this way. Fig. 90 is a fabric which has, in Section A, been raised dry and cut, but raised and not cut in Section B. The difference in the distinctness of the textural effect is quite marked. In A, both warp and weft threads may be seen, and the details of the style, colour and texture are pronounced. These are features which dry raising should give in fabrics, in consequence of the cutting process. When the

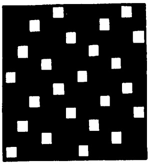


FIG. 88.—Weave for Pattern 89.

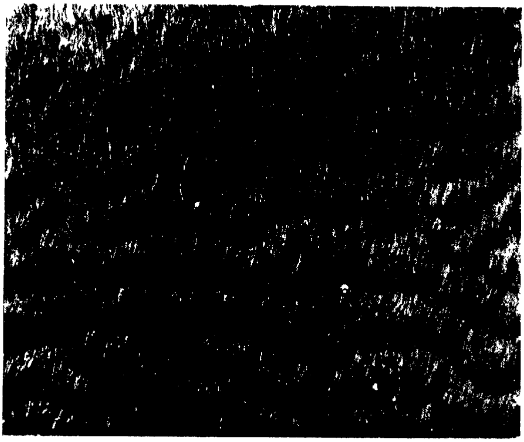


FIG. 89.

fabrics are taken direct from tentering after milling, to the cutting, which is done to obtain a comparatively rough, fibrous finish, cutting mainly clears the face of the cloth of straggling and loose fibre, and even if the operation is repeated, fails to produce the character of surface seen in Section A. In fabrics milled to a small degree, a certain amount of balk or loose fibre develops on the surface, and this can only be effectively removed by first raising dry, and then treating on the cutting machine.

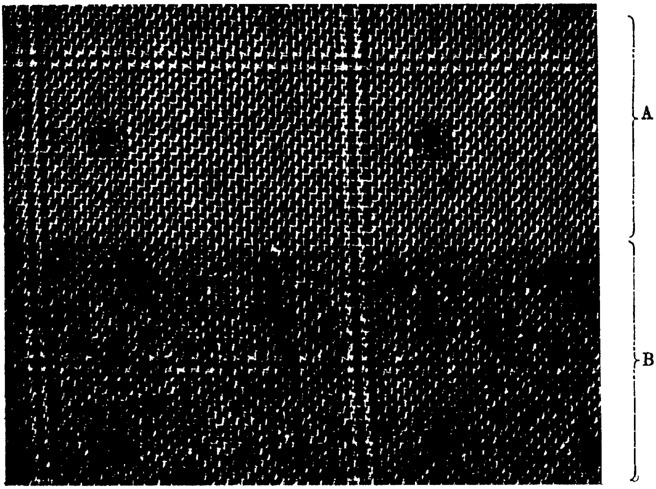


FIG. 90.

The nature of the cloth, woollen or worsted, may modify the distinctness of result, but not the comparative effect of cutting *prior* to, and *after* raising. The explanation of dry raising having such a different effect from raising damp, is, that the wool fibres, when subjected to friction in a dry condition, develop a degree of electricity that renders the wool less pliable to the combing action of the teazles. The fibres resist the raising points so far as laying, straightening, and fixing them in a uniform direction, but are, possibly, as much drawn from the surface of the threads, providing the point of contact with the teazles is equal to that in raising the cloth in a damp state.

(79) *Damp and Wet Raising.*

As seen, dry raising operates on the tangled mass of fibre, the result of milling, but if it is essential that the fibre should not only be raised, but combed and straightened, then the cloth must be, more or less, in a damp condition. The term, *damp*, is used here as distinct from the term, *wet*, which condition imparts another quality to the fibrous surface obtained. The dampness of the fabric does not lessen the effectiveness of the raising points when brought in contact with the cloth, but the fibres are drawn in a line, and in consequence of being straightened and worked in one direction, a face or lustre is acquired on the texture. It follows, that all dress-face cloths are, in the raising process, treated in this condition. By raising the piece from the beginning to the finishing end, reversing and repeating the operation several times in succession, a full pile of fibres is obtained, and brightness of finish.

Wet raising is the process which involves the greatest diversity of treatment in finishing. This will be understood if the raising routine of a woollen doeskin, or a beaver, is described. Finishing here, as regards raising, consists of treating the cloth several times at different stages of work. Prior to dyeing, the piece is practically finished, or possesses a fibrous face. Raising commences after milling, comprising at least five operations from the "tail" and "head" end alternately. After tentering and drying, what is termed "dry beating," that is, steaming and raising to lay and level the fibres, is done. Then follow the processes of cutting, brushing, recutting, rebrushing, steaming and pressing. In this way, a face or pile of fibres is developed which, by a process of boiling repeated several times, is made permanent. Subsequent to dyeing the piece is again raised, tentered, and, after blowing with steam, raised to finally straighten the fibre. The processes of cutting, blowing with steam after cutting, brushing and steaming, and pressing, further fix the lustrous finish. An interesting feature here is the nature and variety of raising. The first raising following milling is the most important for getting up and laying the fibre, but the slighter raising, termed "dry beating," following drying, the severer raising after dyeing, and a second dry beating which takes place after tentering and dyeing, are useful in developing the "face" finish.

The doeskin finish, so typical of wet raising, may be applied to cloths with a warp or a weft face. The real doeskin is the former, the weave being five or eight-end warp sateen. In the production of union pilots and beavers, in which cotton warp and low woollen weft are used, a like finish may be produced though the cloths have a weft surface. The difference in the raising routine of the doeskin and the union imitations, both as to the quality of pile and the effect on the yarns, should be explained. Examining and testing the warp threads in the doeskin after raising, show that they have suffered somewhat in strength, but have only a slight fray of fibres; but the yarns removed from the union fabric, similarly raised, have quite a shag of fibre, and have suffered in strength. It has been shown (Chapter II.) that raising across the thread has a different effect from raising on the length of the thread, and these two fabrics, doeskin and union beaver, are examples. To develop a full pile in the union fabric, raising across the yarn is necessary for the simple reason that it is only the weft yarn which has raising quality, yet the finish of the cloth must give a fibrous face in which the pile is raised on the length of the fabric.

(80) *Raising Determined by the Degree of Felting.*

All cloths, unless unduly loose in structure, may be raised to a degree. Thus, fine, thin fabrics, such as costumes and dress materials made of woollen yarn, or of worsted warp and woollen weft, are raised, though only having a moderate amount of felting. Raising may be done on the piece when in the grease, but this is chiefly for the purpose of felting the raised fibre into the foundation of the cloth in scouring and milling. Raising is definitely affected by the quality of the fibre, the structure of the yarn, and the firmness of the fabric as produced in the loom, and especially by felting. There are instances, as for example, in low-class blankets and rugs, where a soft and full pile of fibre is wanted, but not laid in a particular direction, where the operation of raising is done after preparatory milling: but to raise to the extent as in a beaver or billiard cloth, so that the surface is actually covered with a dense pile, requires excessive felting before the fabric is subjected to the action of the raising machine, as shown in the doeskin.

Felting, as explained, gives a hard, close texture, with the fibres of the yarns intermatted or milled together, and even the yarns themselves, in some cloths, formed apparently into a piece of felt. Raising, in such instances, does not so much draw and comb the fibres from separate threads of warp and weft, as from a compact texture, where the surface is covered with a quantity of milled fibre. This is exactly the nature of fabric adapted to repeated raising, especially when the cloth is in a damp or wet state. The fibres may be raised, straightened, drawn into a line with each other, and yet adhere to, and compose a permanent part of the face of the fabric.

(81) *Quality of the Material and the Raised Result.*

Textile fibres have different raising qualities. Vegetable, animal and silk fibres may be used separately, or in combination, in fabrics in which raising is practised, but hard threads, such as linen, do not raise satisfactorily. For example, if a texture with a linen warp and silk weft were raised, in a short time a shag of fibres would be formed on the silk weft, but there would be no such effect on the linen warp. A soft spun linen weft would raise, but not in the same way as woollen or silk. On the other hand, jute is a vegetable fibre that raises well on the teazle gig, the operation softening the character of the pattern in the fabric: it is mainly adapted to jute textures for tapestries, curtains and hangings.

Fibres of wool, mohair, alpaca, and camel's hair, are more suitable for raising than those alluded to, and hence it is in fabrics made of such materials that raising is more frequently and successfully done. In the use of wool, the densest pile is producible, the coarser the wool the less dense being the pile.

Two very different effects are seen in the patterns (Figs. 91 and 92) one a Cheviot, and the other a Saxony cloth, both made of the same counts of yarn and submitted to the same amount of milling and raising, with two very different effects. In the Saxony, there is a much fuller or denser pile of fibres than in the Cheviot, which will be well understood by those acquainted with the yarns which result from the use of fine and coarse wools. The Saxony yarn, equal to a 60's quality worsted, may contain about 50 per cent. more fibre than a Cheviot yarn equal to a 20's quality worsted. It must follow that, in the fabrics made of these two yarns, when felted and raised, the Saxony possesses a much closer and denser pile than the Cheviot. An examination of the fabrics shows that the Saxony

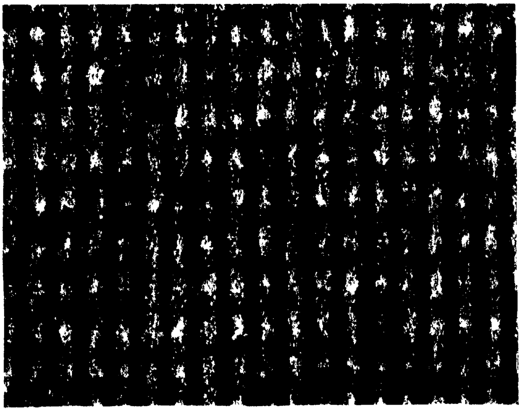


FIG. 91.

has a soft, full pile of fibres, but shorter in the staple than that of the Cheviot, and this latter characteristic is noticeable in the two illustrations. In Fig. 92 the checks of black and white are quite defined, and there is little indication of the trail of white fibres over the black checks, or the black fibres over the white checks. How different in the Cheviot pattern (Fig. 91) in which the mingling of black and white fibres from the respective checks destroys that clear definition of black and white spaces noticeable in the Saxony, and results in an intermediate grey shade. The marked dissimilarity between the two textures suggests the variety of pattern of cloth obtainable, by combining these two yarns in stripes, checks and other forms; but it is the nature of the pile due to the difference in the quality of fibre which is here the chief feature.

Cheviot tweeds are not usually raised, the object of the finishing being to retain the natural features of the wool or raw material, but certain styles of fabrics made from Cheviot or Crossbred wools are raised for a special finish, as in rugs, and medium and coarse qualities of blankets. In the Irish frieze there may not be actual raising, but in felting a nap is formed, having some of the qualities of a raised texture. Dry raising is not usual in the finer Cheviots, but when a Cheviot cloth approaching a Saxony in appearance is wanted, such may be milled, raised and cut clear.

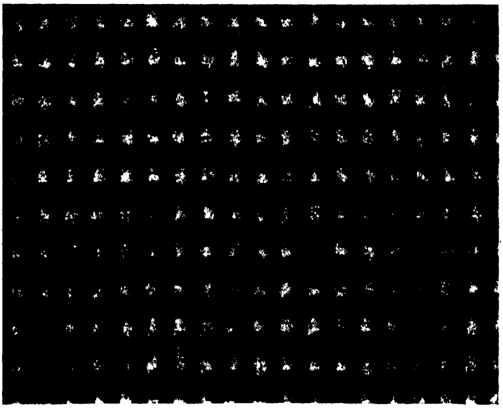


FIG. 92.

Saxony cloths undergo more diversified routine than is possible in fabrics made of Cheviot and Crossbred wools. In some instances, raising is done to produce a clear surface, but in other cloths, to give, in different degrees, a soft and ful fibrous pile. This pile may be developed on both sides of the cloth, as in travelling and carriage rugs, or it may be simply a quality of the face of the cloth, or, if a compound fabric, of the back of the cloth with the face clear in weave, colour and pattern.

Fabrics of the Saxony type may be classified as to raising as below:—

(1) Cloths with a pile of fibre on both sides.

(2) Cloths with a soft finish.

(3) Cloths with a soft fibrous lustre or dress-face finish.

(4) Cloths in which the face is a clear finish, and the back of the fabric raised.

The nature of the finish is determined by (*a*) the make of the fabric; (*b*) the materials used; and (*c*) the application of the fabric.

The first class includes blankets, rugs, shawls, travelling mauds, golf cloakings and fabrics which may require to be finished on both sides, the object being to get the greatest possible fulness of handle. By raising damp, a vertical pile is formed which is made fuller by treating the pieces on the "beating" frame. The distinctive feature of this raised surface is, that it is not readily damaged or marked by moisture.

The second kind of raising, which gives a soft texture, may be defined as semi dress-face, and is adapted to light-weight suitings, costume and dress fabrics. Such fabrics are slightly or moderately milled. The finish applied is chiefly due to damp or moist raising. If the colours in the fabric are not bright and fast to milling, and the pattern of a simple stripe or check character, the fibrous condition is fixed, and the brightness of colour improved by blowing the cloths with steam. It is not desirable to practice boiling with thin fabrics of delicate colours, as by effective raising and steaming, a sufficient "face" may be obtained.

In the third class of Saxonies, the most heavily raised fabrics are comprised, namely, superfine plain cloths, billiard cloths, doeskins and beavers. As shown, the raising routine here is of a diversified nature, and modified as to the quality of the material, structure of the fabric, and lustrous quality of the finish which has to be acquired.

The Saxony textures mentioned are raised moist or wet to give fulness of pile and softness of handle, but in the fourth class, raising is done either damp or dry, to accentuate the distinctive elements of the pattern, and face of the fabric.

(82) *Raising and Weave Structure.*

The several types of woven surfaces, such as warp, weft, and warp and weft equal, and the manner in which they are affected by raising, have been defined; but weave and fabric structure may be varied in each of these three principal types. Some analyses may be made of these textures, illustrated in Figs. 93 to 96, as they behave in the raising process. Fig. 93 is an ordinary sateen, with the twill in the reverse direction to the twine in the yarn, giving a venetian pattern, having four-fifths warp to one-fifth weft on the face, so that the raising is chiefly on the warp and has little or no effect on the weft. The fabric has a soft, fibrous quality, the twill effect being scarcely visible. Raising is on the length of the thread, giving a straight draw of fibres.

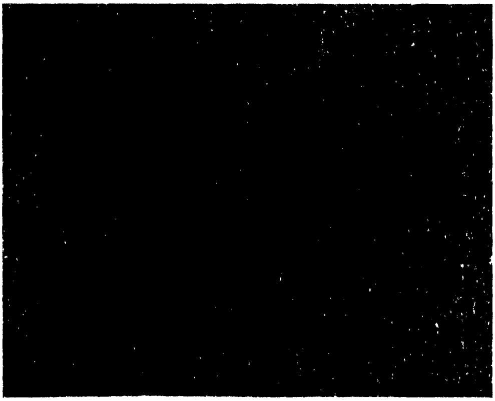


FIG. 93.

Figs. 94, 95 and 96 are illustrative of compound weave surfaces: first, of fabrics with a warp face and weft face alternately; second, of fabrics with a warp face in the ground portions and weft cord for striping; third, of check patterns developed in weft cord with $_2\backslash^2$ twill backed in the weft for ground. The particulars of manufacture of these cloths are as follows:—

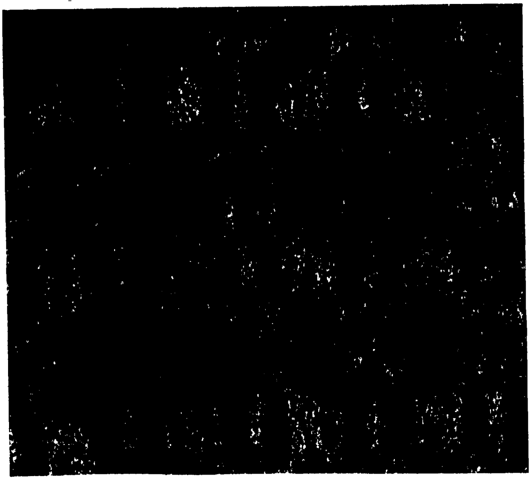
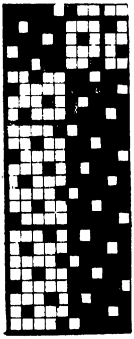
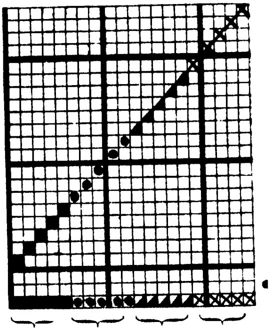


Fig. 94.



Plan 94A.



A	B	C	D
→ 20	10	5	10
10	20	10	5
5	10	20	10
10	5	10	20

Plan 94B.—Healding draft.

Fig. 93 (Plan: 5-end sateen) and Fig. 94 (Plan 94A).

Warp and Weft: 20 skns. Saxony, 10's reed 4's, 40 picks per inch.

Set 72 inches wide in the reed for 56 inches finished.

Fig. 95 (Plan 95A) and Fig. 96 (Plan 96A).

Warp and Weft: 30 skns. Saxony, 12's reed 4's, 80 picks per inch.

Set 72 inches wide in the reed for 54 inches finished.

The block check, Fig. 94 (Plan 94A, Healding Draft 94B), is composed of warp and weft face weaves, so that raising is on the length of the thread in the warp, and across the thread in the weft. This pattern is an example of one of the principles of raising, namely, that a smoother pile is obtained by raising on the length of the thread, and a rougher pile by raising across the thread. Warp and weft face weaves, such as are here combined, are used in designs for costumes, mantles and vestings, the spotting or figuring developed in weft having a different appearance, as a result of raising, from the warp ground. Not only warp and weft sateens, but warp and weft twills are used for a similar purpose.

Cord weaves of the weft type, Fig. 95 (Plan 95A, Healding Draft 95B), have other textural qualities when considered in relation to raising. In Fig. 95, the cords run lengthways of the piece, a solid weft surface being in contrast with a warp twill, the yarns in both being of a similar quality, and the raising contact in the direction of the warp. The cord sections form a special feature in raising. Should the raising be across the fabric, the fibres of the weft cord would be trailed over the edges of the stripes of warp effect, but by raising lengthways, the fibre in the weft forming the cords is got up, and the piping or cord lines remain clear at the edges though softened in appearance.

Raising across the weft when the cords are in a line with the weft has a very different effect, as shown in Fig. 96; the action of the raising points on the lines A and B in the warp is similar, but on lines C and D the fibres are drawn over a portion of the weft twill. Clearly, the cords running warp ways are as fibrous, after raising, as those across the fabric, but the teazles moving in the line of the cords, simply straighten the fibres in the same way, whereas in cord C, similar to A, but across the fabric, the fibres are more disturbed, being combed beyond the actual woven dimensions of the cord.

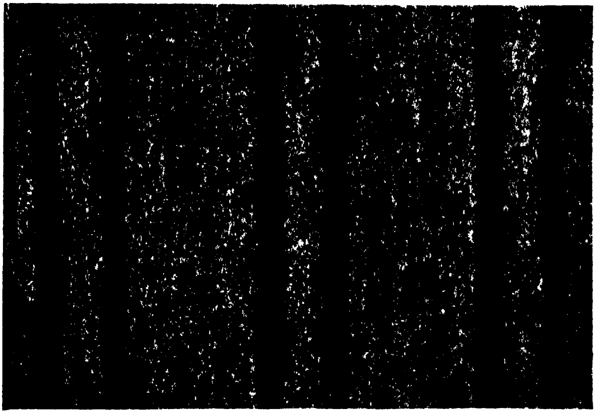
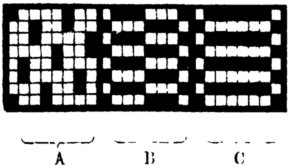
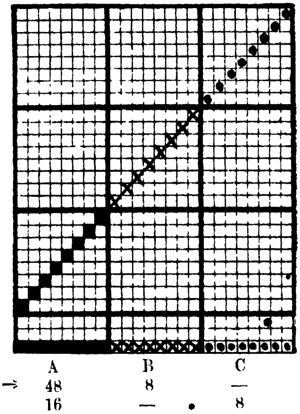


Fig. 95.



Plan 95A.



Plan 95B.—Healding draft.

(83) *Quality of the Fibre and Yarn Structure.*

Examples may now be considered in which mohair yarn is used in certain sections of the pattern, illustrated in Figs. 97 and 98, with similar counts of ground yarn and the same setting as in Figs. 95 and 96. In the first of these examples, the weft is one pick Saxony and one pick of 12's mohair. The felting is similar to that of Fig. 95, and, on leaving the loom, the mohair cords in the fabric have an ordinary plain surface.

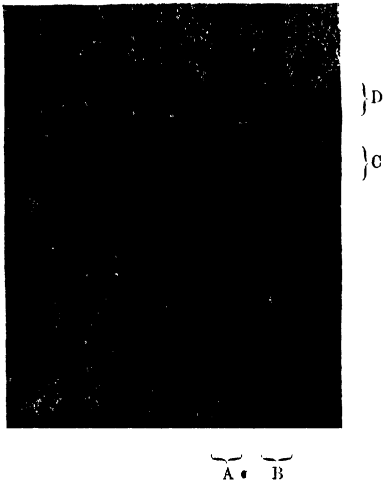
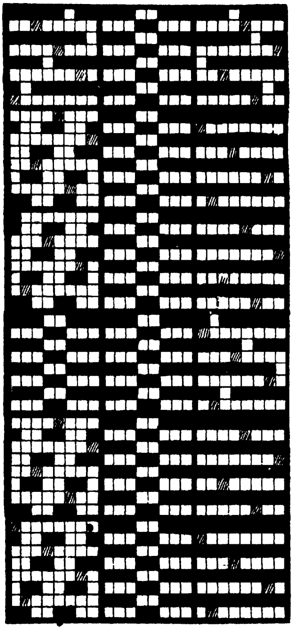


Fig. 96.

The difference between Figs. 95 and 97 is due entirely to changing the weft yarn forming the cord. This long-fibred lustrous material is of less felting property than the Saxony yarn, so that, in milling, it curls or loops. Raising follows, and if this is done when the cloth is in a damp condition, the wavy effect and the irregular shagginess of fibre are produced, observed in Fig. 97.

The quality of the mohair as a raising material is equally distinctive in Fig. 98 (Plan 98A, Healding Draft 95B). This, as will be seen, is a backed $\frac{2}{2}$ twill, with every 16th pick floating over eight threads in Sections A and B, bringing the mohair, which in other portions is on the back of the fabric, on to the face. It forms a mere spot on the dark line due to using dark warp threads in this section of the pattern. Raising draws the mohair fibre over this line, and produces an appearance of short tufts of fibre inserted into the fabric after weaving.



PLAN 96A.

It has been shown by the specimens referred to in Figs. 95 and 97, that the nature of the fibre used in the manufacture of the yarn results in distinct raised effects, though the fabric structure may remain the same.

Research has been made to further illustrate raising on this kind of material; and fabrics have been specially designed, the weft forming the face only, and composed of Cheviot and mohair, Saxony and mohair, and Cheviot, Saxony and mohair yarns. These materials were woven in stripe and check form. Raising was done, first, on the length of the thread, and second, across the thread, and with the fabrics in dry and moist conditions.

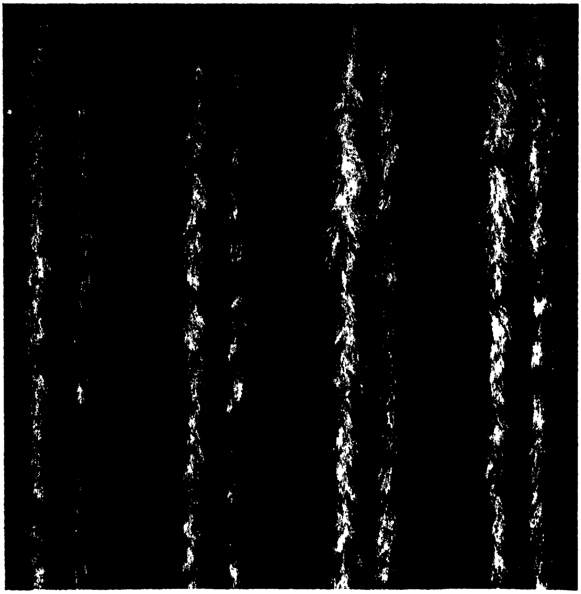


FIG. 97.

In order to understand the nature of fibrous pile obtainable by using such yarns in textures constructed on these lines, reference will be made to Figs. 99, 100 and 101 (milled), and Figs. 102, 103 and 104 (milled and raised). The warp in each case is cotton, and the plan, a reversible weft weave, so that in Section A of Fig. 99, the mohair is on the face, and in Section C, the Saxony yarn. It will be seen that, even in milling, a number of mohair fibres have worked through from the back

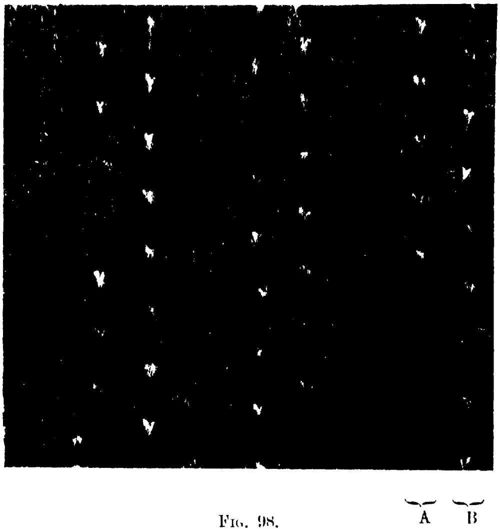
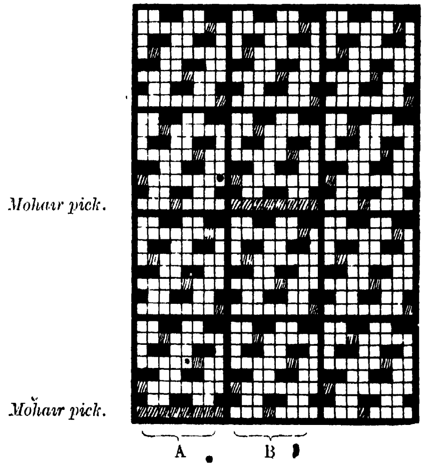


Fig. 98.



Plan 98a.

to the face in Section B. The wefting of Fig. 100 is two picks mohair and two picks Saxony; the intermediate spaces A, are, therefore, equal to pick and pick on the face, and the same on the back. Where the picks interchange from face to back, Section B, the curliness is developed in milling. Fig. 101 is woven one pick mohair, one pick Saxony and one pick Cheviot yarn, so that Sections A and B are composed equally on the face and on the back of these yarns, but the reversing of the positions of the picks occurs with the interchanging of the weave.

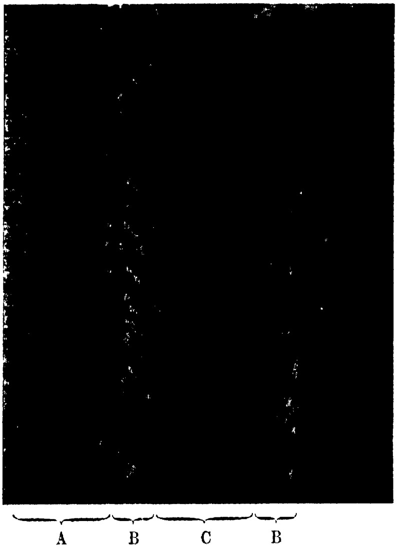


FIG. 99.

It is not necessary here to explain how the curliness or buckles have been developed, but rather to show that such fibrous surfaces as Sections A and B in these respective cloths (Figs. 99, 100, 101) have distinct raising properties.

Comparing the raised specimens, Figs. 102, 103, and 104, the

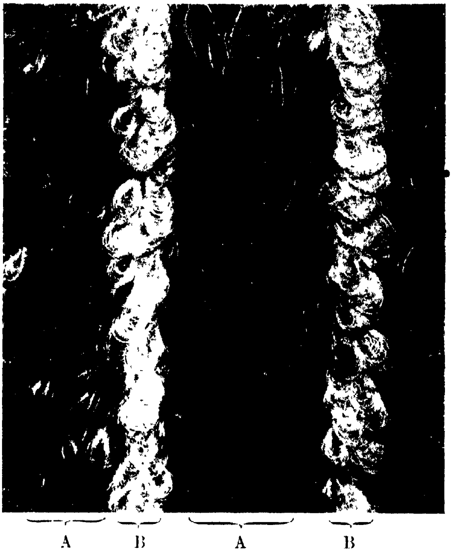


FIG. 100.

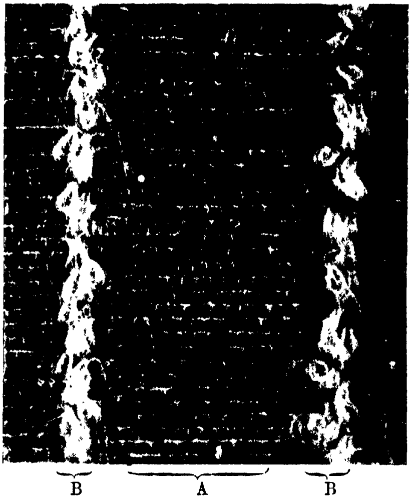


FIG. 101.

appearance and effect in each fabric are quite different. The curliness so characteristic of the felted cloths has been combed out by the action of the teazles, and the mohair sections have become a shag of fibres. Another distinguishing feature is the intermingling of the fibres of the Saxony, Cheviot and mohair yarns used in the weft (Fig. 104). From each a proportion of fibre has been raised, producing a similar effect to the processes of blending and carding of materials of different qualities and shades. In stripes B, the effect is seen of bringing the mohair yarn on to the face of the cloth. An irregular pile of fibres is produced with some of the features of a plush fabric. The mohair fibres of the weft on the under side also impart character to the texture. Some lessons as to the influence of lustrous and comparatively straight fibres might be drawn from this illustration, but it is now a question of how they influence the appearance of the face of the fabric by raising. A two-ply texture,

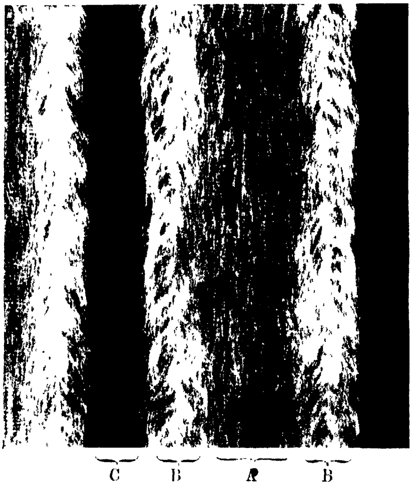


FIG. 102.

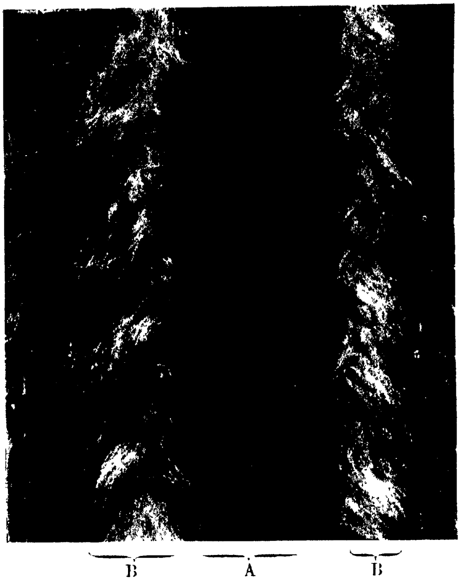


FIG. 103.

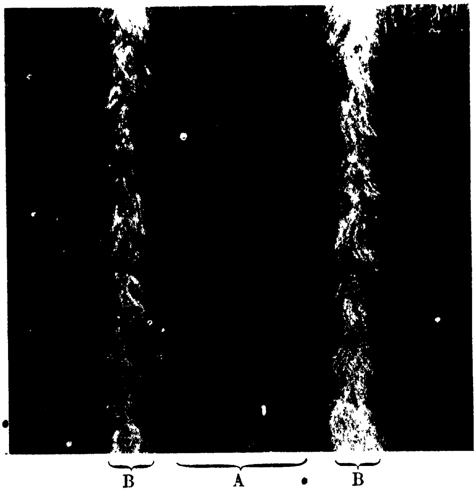


FIG. 104.

woven one pick Saxony (face) and one pick Cheviot (back), when raised on each side, possesses the characteristics of each kind of yarn only. But the use of a fibre like mohair in a threefold texture, on the face, in the centre or on the underside, has some effect, when raised, upon the nature of the woven surface treated. This is specially noticeable in the series of experiments from which the pattern given in Fig. 101 has been taken.

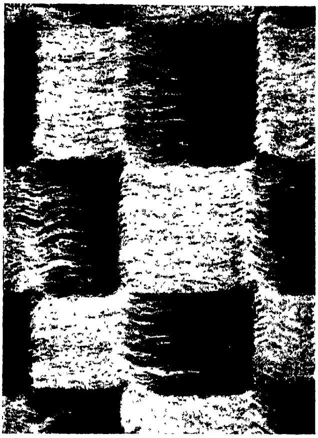


FIG. 105.

Some check patterns of a similar construction, composed of the same yarns, offering other raising characteristics, are illustrated in Figs. 105, 106. These show the difference in effect of raising two adjacent woven surfaces made of Saxony and mohair yarns. The examples indicate the diversity of raised effects, and the possibility of acquiring, in this finishing process, qualities of texture not producible by other methods. The nature of the fibre, yarn, and fabric construction, modify the raising routine and textural character.

Contrast, in the first place, the effect of the raising action in these fabrics when operating in a line with the weft (Fig. 105) and across the weft (Fig. 106). They do not appear to be of the same woven structure, with the exception of the style of pattern. The mohair yarn is the cause of the chief points of difference. Raising in the line of the weft (Fig. 105) combs up a shag of fibres, slightly wavy owing to the manner in which these parts are affected in milling. The combing and straightening action is apparent. It has laid and spread the fibres over the face of the fabric. How different in the cross-thread raising (Fig. 106). In this texture there are wavy, undulating lines of lustrous fibre, running in stripes down either side of the black and white checks. Further, there is a marked contrast between the spaces of mohair and of Saxony cloth. In the straight-thread raising (Fig. 105) the fibres are drawn from the side of the spaces, where the protruding mohair yarn is brought in contact with the teazles, and trailed over the Saxony weft portions of the pattern. The effects are exaggerated by using mohair, alpaca, or lustre worsted, but they would also be present, though in a less degree, if Cheviot, Saxony and other yarns had been used. One feature which, however, would not result is that due to the buckling or curling in felting (see Figs. 99, 100, and 101), but

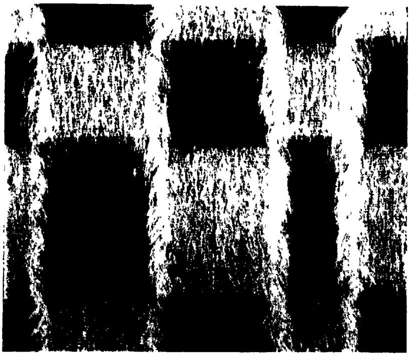


FIG. 106.

the direction of the fibre in the two kinds of raising, and the relative density of the pile, would correspond to those in the examples.

There is another feature for comparison, namely, the condition of the fabric as to moisture, Fig. 106 having been raised dry, and Fig. 107 raised damp. In dry raising, with material like mohair, the fibre is easily disturbed on the surface of the texture, and if the action of the teazles is carried too far, the density of the pile will be impoverished. This is seen if the grey sections in the two illustrations are contrasted. The fabric raised damp has a comparatively fuller and more uniform pile. This applies to figured fabrics, as well as to those shown, in which such materials are used as in the specimens.

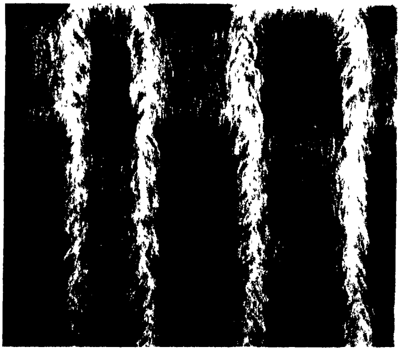


Fig. 107.

An example of a tapestry fabric raised damp is given in Fig. 108. It will be noticed how different are the surfaces in the respective portions of the figure, apart from the change in shade. The densest pile is on the medium shade, which is Saxony yarn, then follows the dark shade, Cheviot, and the lustrous surface, the mohair. The structure is three-ply in the weft, similar to Fig. 104, and the respective sections of the pattern may be changed as to the material in which they are developed. Raising is here effective in giving novelty of character

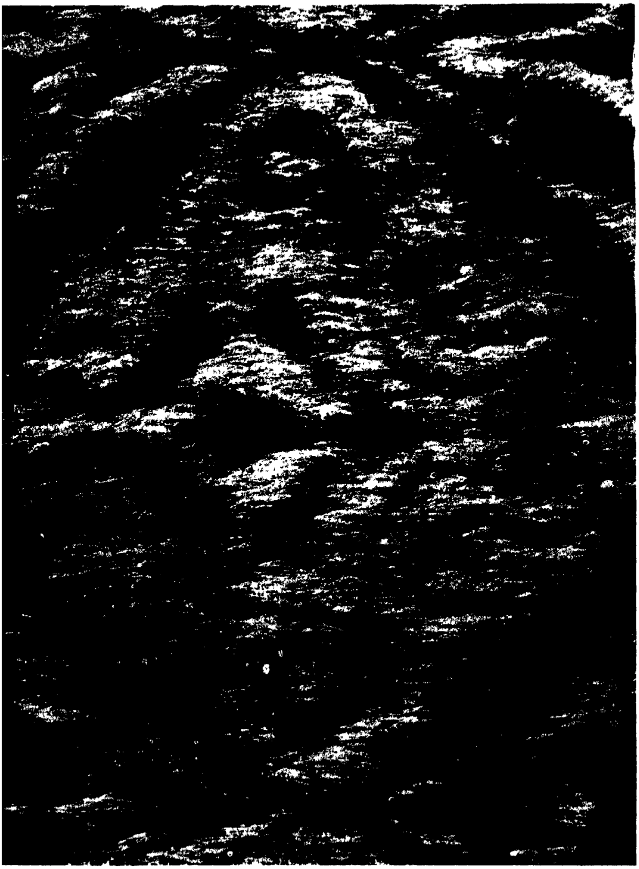


Fig. 108

to what would, otherwise, have been a clearly outlined pattern: it softens and tones the edges of the figuring, and destroys the fine detail, but where the style of design consists of fairly large spaces and forms, it is a system of finishing which imparts the specific qualities indicated.

(84) *Raising of Fabrics in which Special or Fancy Yarns are used.*

As shown, raising is one of the processes of finishing which may be useful in giving novelty of texture and design. It will be helpful to see how the theories which have been defined, may have, in the fancy trade, important results. Examples will be analysed (Figs. 109, 110 and 111) in which (1) a shaded check is obtained by applying mohair to a Saxony ground; (2) in which flake yarns are used in the warp; and (3 in which curl yarns form checking lines in both warp and weft

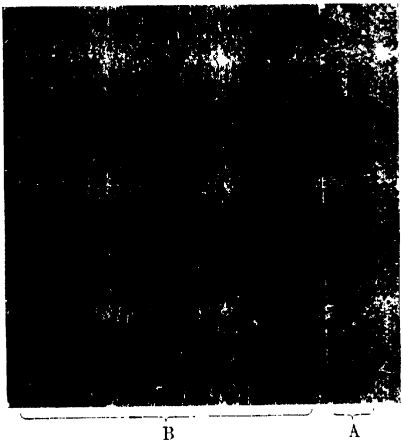


Fig. 109.

These examples show the utility of using fancy yarns on Saxony and Cheviot grounds. The shaded check (Fig 109) is a pattern produced or developed in raising, Section A being unraised, and Section B raised. As is well understood shaded patterns are obtainable by weave, methods of warping and wefting, and in compound cloths. Here, mohair yarns ar suitably grouped in the warp, and in the weft, in combinatio with Saxony yarns. There is, after milling, some shaded effect, but it is in raising where the softness and graduated shading

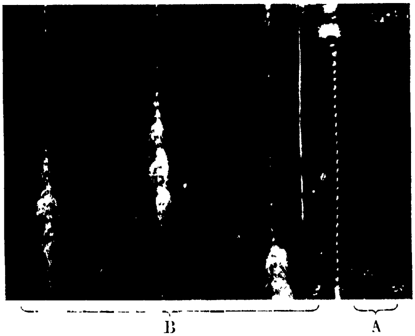


FIG. 110.

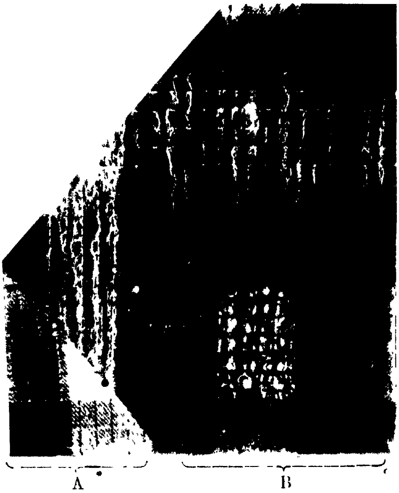


FIG. 111.

are chiefly developed. Had the fabric been made of one quality of warp and weft, then this softness of tone would not have been possible to the same degree.

Costume, vesting and mantle cloths, in which fancy yarns, such as knop, flake, curl and mohair are used, and the textures raised, give results similar to those seen in Figs. 110 and 111, the former being a costume fabric with a large knop-twist yarn inserted in the warp, and the latter, a check style in a twofold fabric with a fine ground and mohair checking yarns. In Fig. 110, Section A is unraised, and Section B raised: in Section B, the long fibres appearing on the face, impart a grey tone to the fabric, and there is an absence of the thready characteristic of Section A.

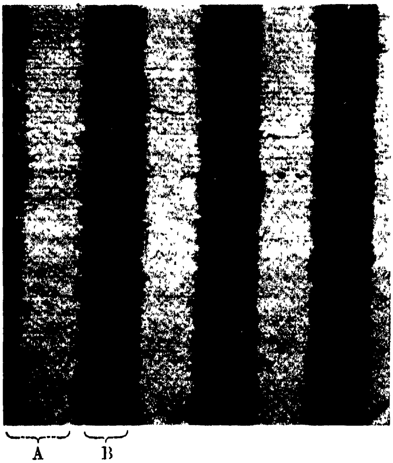


Fig. 112.

One further comparison or contrast in the woven and raised effect is seen in Fig. 111. The difference is emphasised by the length and lustre of the mohair yarn which modifies the groundwork of the texture. Before raising, the checks of white, brown and intermediate shades, Part A, are quite distinct, and possess clearness of definition, which, in large patches, form unsatisfactory, if not displeasing and inartistic contrasts. The drawing and trailing of the mohair checking lines on these squares of colour, has given the subduing and mellowing quality of

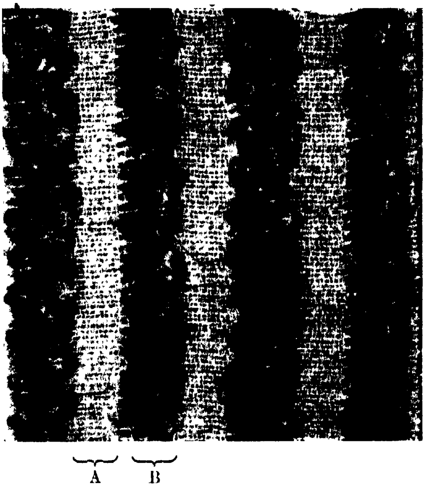


Fig. 113.

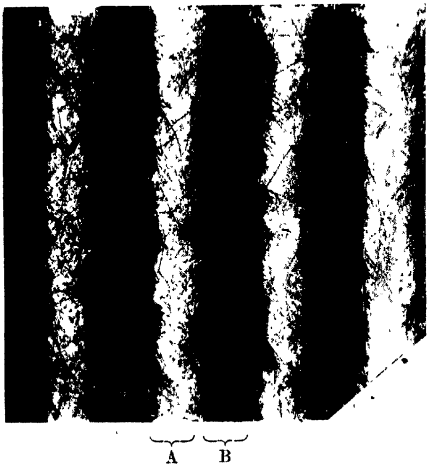


Fig. 114.

tone so distinguishable in this example. The bright touches of colour, helpful in imparting freshness to the style, are not, by the process, obliterated, but are, if anything, made increasingly valuable in lending beauty of textural quality and colour contrast.

Four textures specially designed to emphasise the difference in the milling and raising qualities of the yarns, are given in

FIG. 115.

Figs. 112 and 113 (milled only), and Figs. 114 and 115 (milled and raised).

The milled results are interesting, and suggestive of certain theoretical principles in the weaving and felting of such fabrics; for, as seen in Figs. 112 and 113, Sections A are perfectly level as in an ordinary texture; Sections B, curled or buckled, Fig. 112 having the appearance of a terry pile, and Fig. 113 of a curl, due either to the use of a folded yarn or some principle of pile weaving. Raising in both examples removes the loop pile characteristic. Comparing Fig. 112 with Fig. 114, raising in the latter pattern has disturbed the surface fibres, and changed the curliness into a comparatively long shag or velvet pile. The difference between Figs. 113 and 115 is somewhat more striking, two kinds of yarn having been used in Section B, of Fig. 113, namely, mohair and camel's hair, which have not raised exactly to the same degree. The stripes B in Fig. 115 have a more wavy quality than in Fig. 114, but the contrast between the Saxony surface and the surface due to the lustrous yarns is still well marked.

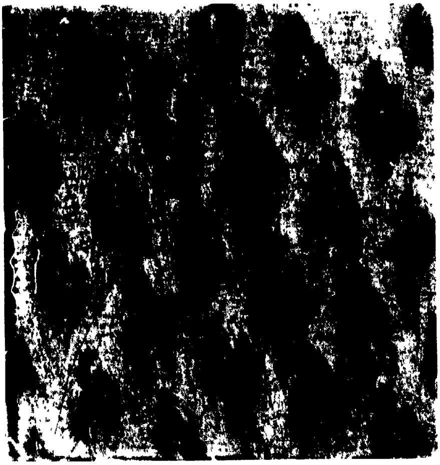


Fig. 116.

That this is a useful scheme of weaving, milling, and raising, is not only clear from these patterns, but from the spotted effect (Fig. 116) which shows that several designs are possible, and that successful imitations of woven pile fabrics may be made by milling and raising, for the spots are regularly distributed, and there is an equal amount of shag or fibre in each. It is a method of fabric production which is capable of being utilised, when treated on the lines defined, in mantle, costume, decorative and other fancy fabrics.

CHAPTER IX.

RAISING MACHINERY AND THE RAISING PROCESS.

(85) Hand Raising. (86) Raising Gig. (87) Operation of the Raising Gig. (88) Two-Cylinder Raising Gig. (89) Teazle Raising. (90) Teazles and Card-wire compared. (91) Card-wire Raising Machines. (92) Modern Card Raising Machines. (93) The Horizontal Machine. (94) Rotary Machines.

(85) *Hand Raising.*

RAISING was formerly a hand operation. The teazles were fixed in frames as seen at Figs. 117 and 117A. The teazle, as in gig raising, varied with the character of the fabric and the hardness of the surface of the cloth. The frames were drawn alternately across the texture, the points of the teazles being kept in contact with it. The piece was spread in lengths on a padded board fixed at a suitable angle and height. The upper and lower ends of the board were mounted with card-wire or clothing for maintaining the length of cloth being raised, at the proper tension and evenness. By this method, the fabric could be raised either warp or weft way, so that in one sense, hand raising had an advantage over gig raising, which is limited to treating the piece in the direction of the warp. It was, however, a slow and tedious operation. Still, such raising is useful in combination with the gig, producing the fullest pile and softest handle on certain makes of woollen cloths.

(86) *Raising Gig.*

The oldest type of machine for this process of finishing is the "gig" (Figs. 118 and 118A). It consists of the main cylinder C, a number of guide rollers G, G^1, G^2, G^3, and G^4; folding motion

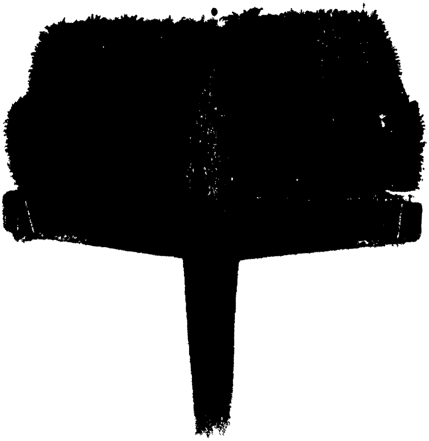


FIG. 117.—Hand Raiser (*Small Teazles*).

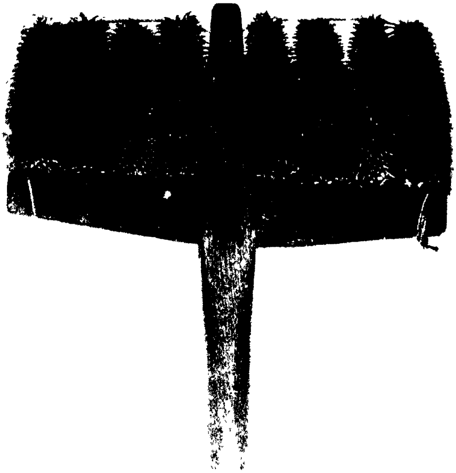


FIG. 117A.—Hand Raiser (*Large Teazles*).

F; the scray S; the expanding roller E; and the rack for the expanding roller R. The teazle rods or frames—twenty-four or

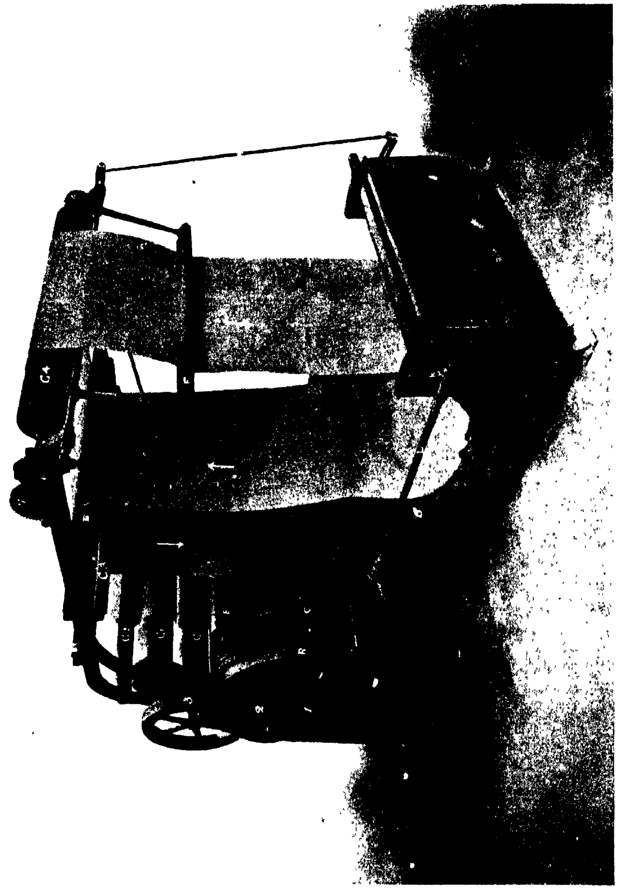


Fig. 118.—Raising Gig with Cloth

more in number—are arranged in the cylinder or gig. This cylinder, usually 40 inches in diameter, makes from 150-160 revolutions per minute.

The actual measure of cloth in contact with the raising points during the operation of the gig, may vary up to 25 inches, according to the position of the expanding roller in the rack. Motion is imparted direct from the driving pulley P^1, on the central shaft running from end to end of the machine. The strap is moved from the loose to the fast pulley, either in the ordinary way or by the screw arrangement M. To put the machine out of operation, the strap is taken from the fast pulley P^1 on to the loose pulley P, and the brake, controlled by handle N, is used for rapidly checking the movement of the cylinder. The main shaft carries a pinion 1, which meshes with pinion 2, imparting motion to wheel 3, on the shaft of which is a wheel driving G^1. Draw rollers G and G^1 cause the piece to travel in the direction indicated by the arrows.

The folding motion is driven by wheel gearing on the shaft of roller G. The shaft D, which extends along the top and side of the machine, is mounted at the front end with a bevel wheel 5, gearing with wheel 4 on the shaft of G^4, at the other end of which are wheels 6 and 7, and also crank and lever gearing, which give a backward and forward movement to the folder F.

The scray, operated by means of connecting rod H between levers I and J, moves the piece lying in folds gradually forward. This scray is an endless lattice apron, directly actuated by lever J, mounted with a catch engaging the catch wheel (not shown) on shaft K, which turns cross-shaft L, driving the shaft at the rear end of the scray.

(87) *Operation of the Raising Gig.*

Fig. 118 is the machine prepared, or "dressed," for raising a piece of cloth. Guide rollers and tension bars keep the piece perfectly even and level, and at a constant tension. Any defect of this kind would result in the action of the teazles being uneven, and in the development of streakiness or teazle marks.

In starting the machine, the tail-end of the piece is taken over the tension bar B, under roller G^3, over B^1 and under the expansion roller E, over the surface of the gig, and round guide rollers G, G^1 and G^2, and over B^2 to the guide roller G^4 at the front of the machine, then between rollers of the folding motion F back to the scray.

The degree of raising for each round of the cloth, the length of cloth treated at each revolution, and the closeness of contact with the teazle points, are determined by the setting of the expanding roller E. In dry raising, only a minimum length of fabric is acted upon at one time, but in damp, or wet raising, the expanding roller is lowered in the rack after each process, gradually developing density of pile.

The draft in raising is fixed by the relative speeds of the cylinder and of the movement of the cloth. Taking the surface speed of the gig as about 1,600 ft. per minute, and that of the piece 80 ft., the draft would be in the ratio of 20 to 1. This gives some idea of the combing and straightening out of the fibres which is effected during the operation.

"Dry-beating" is a process done on the raising gig, a steam box being fixed in the position of roller G^3, Fig. 118, with a perforated roller extending from end to end, through which the steam passes. The object is not so much to raise, as to straighten the fibres, and also to prepare the pieces for cutting.

(88) *Two-Cylinder Raising Gig.*

Several improvements have been added to the ordinary raising gig, one of which consists in setting the teazles at an angle, in order to obtain a more equal amount of raising on the warp and weft. A second improvement, made by Krantz (Fig. 119) is the addition of another cylinder, which may revolve in the same, or in the opposite way to the first cylinder round which the piece passes. When the gigs revolve to the right and left respectively, what is termed "pile to pile," or "counter-pile" raising results, that is, the teazles act on the cloth in two ways, first opposing the movement of the cloth, and second, drafting with the cloth. This is an effective method of getting up and laying the fibre. It is a system that may be practised with satisfactory results on the rougher, heavy-pile fabrics, such as rugs and blankets, and the coarser qualities of cloths where a rough pile is a feature of the finish.

The cloth is taken from the cuttling board, over guide roller G, under G¹, round the expanding roller E, coming in contact

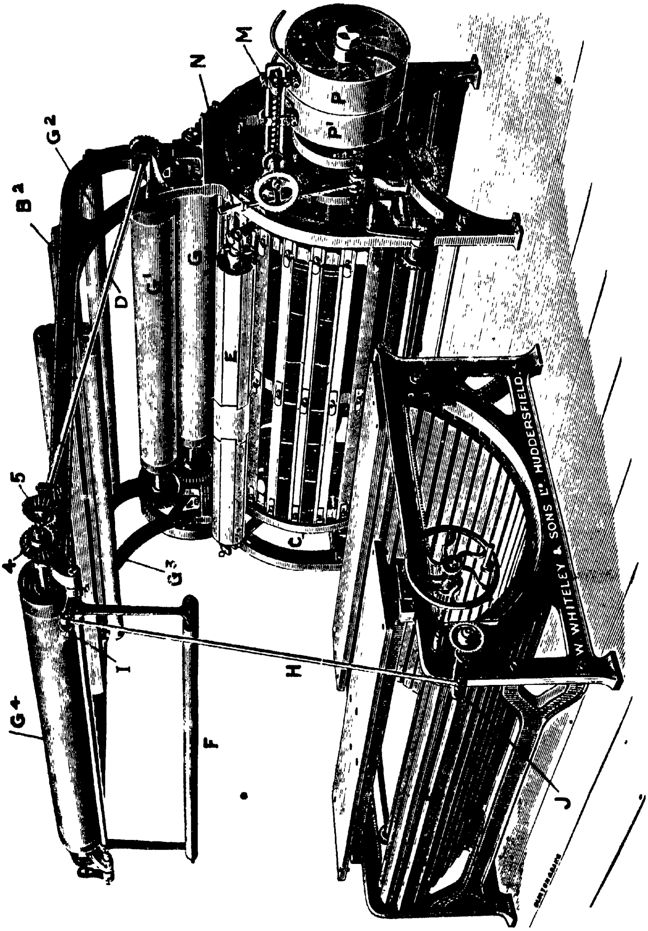


FIG. 118A.—Raising Gig without Cloth.

with the teazles in cylinder A, then round G² and upper expanding roller E¹, and round the positively driven cylinder B. There are tension bars, as shown, for each cylinder. After the last contact with cylinder B, the piece passes over guide roller G^3 to the cuttling board. Cylinder A is driven by strap from cylinder B, and as the belt may be either straight or crossed, may be run with or against the cloth as required. There is a damper or spray S, fixed in the position indicated.

(89) *Teazle Raising.*

It will be seen from the natural form of the teazle (*Dipsacus fullonum*) that it possesses diversity of flexibility from the base to the apex, and also greater pliability at the point of each petal than at the root. These are features which, combined with the cylindrical shape, make it specially adapted for raising the fibre on the surface of a woven or felted texture.

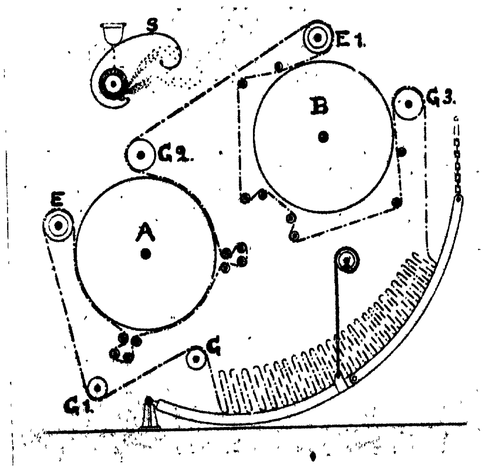


Fig. 119.

Figs. 120 A, B, C, and D, are sections of rods mounted with teazles of different sizes and raising strength. Those in Section A are known as "two's," two rows of teazles of equal size being inserted into each rod. In Section B the teazles in the lower row are larger than those in the upper row: in Section C a medium sized teazle fills about two-thirds of the space across the frame, the smaller space being filled with a row of "buttons," the smallest size of teazle: Section D consists of the largest size, known as "kings," the strongest growth of teazle and the one used for the raising of hard-milled fabrics. New teazles are termed "breakers," and when one side has been used of any kind of teazle, they are defined as "chalked".

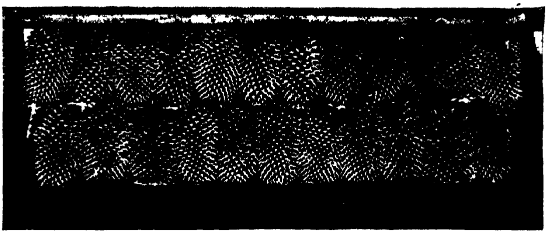


FIG. 120A.

In practice, the frames are arranged variously. For example, first raising should be done with teazles that have been used for some time, and of the smaller kind, as too drastic treatment at this stage is liable to result in waste of fibre. Subsequent raising may be with newer teazles, and with several rods of one kind, following with rods of the medium size, such as Fig. 120B The adjustment and changing of the rods are affected by the character of the cloth being raised, and the pile to be produced.

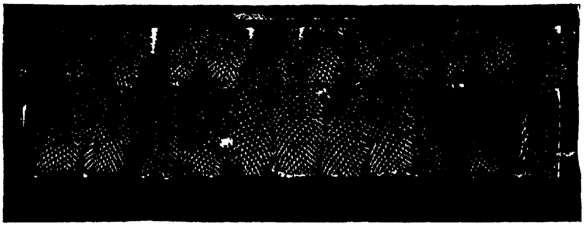


FIG. 120B.

By having the teazles set in two rows (Figs. 120A, B and C), evenness of raising is facilitated. In rods set as in Fig. 120D, there is a ridge between the teazles. To prevent streakiness in raising, when such teazles are used, the rods are so fixed in the gig that teazles of succeeding rods come between each other.

The setting or arrangement of the teazles is a work requiring care and experience. They must be arranged so as to get equality of raising point from side to side of each bar in the gig. If any teazles are more prominent, that is, project slightly more than others, or if they are not of an evenness of pliability, they will have a keener action, and the raising will not be uniform.

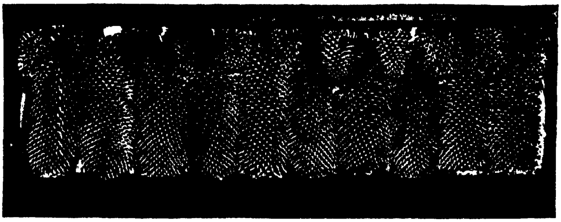


FIG. 120C.

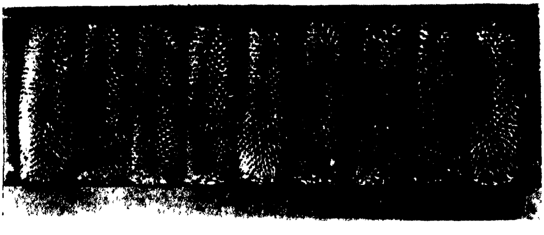


FIG. 120D.

The selection of the teazles, and the changing of the teazles in the bars of the gig, are important in getting a full and close pile. To maintain efficiency of raising, and this economically, it is the practice to change a number of bars, as for example, bars of old teazles alternating with newer ones. Then again, the bars are turned over, that is to say, if the teazles have been used on one side, or "chalked," then by reversing the bars the unused points are brought into contact with the cloth. Another feature which the practical raiser has to observe, is the changing of the teazles to increase the keenness as the pile becomes fuller.

In changing the rods, the teazles which have been used are cleaned of flock by a preening brush. This is brought in contact with the teazles when in a damp condition. After each changing of the rods, they are "chalked" as many as ten to fourteen times in succession.

(90) *Teazles and Card-wire Compared.*

The two raising points in either "hand" or machine raising are the teazle and card-wire. The latter is somewhat similar in point and finish to the clothing used in scribbling and carding. In carding, such wire teeth are for opening the staple of the wool and separating fibre from fibre, reblending or remixing them into a fleece of uniform density. In raising, the revolving cylinders of the machine, covered with wire teeth clothing, are brought in contact with the surface of a firmly-woven and milled texture.

Card-wire raising is more drastic in nature, and more disturbing to the external structure of the yarns, than teazle raising. The more pliable the raising point, the longer the process in obtaining a dense pile, but less destructive to the texture. With a raising point wanting in pliability, and which digs into the threads, it is possible to obtain a pile quickly, but it would be defective in regularity, smoothness and length. The action of the teazle is apparently less severe than a wire point of whatever fineness and shape. The moisture applied to the piece softens the vegetable point, but not the card-wire, so that the teazle point drafts through the face of the texture with a minimum amount of disturbing effect on the structure of the yarn. The process is gradual and progressive, and should result in a close, compact pile of filament, with the foundation of the fabric unaffected in strength and quality. On the other hand, raising with card-wire is adapted, at certain stages of finishing, for producing a dress-finish on both light and heavy fabrics, and also for developing the peculiar character of the "moss" finish. Raising on the card-wire machine is, necessarily, more economical as to time, and number of operations, than teazle raising, but quality of finish is as important in fabrics made of good material as economy of work. To combine the two systems, as indicated, is in some classes of finish and cloths the better plan.

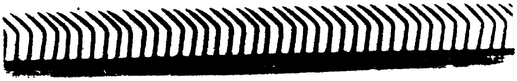


FIG. 121.

The card-wire for cotton fabrics, and also for fabrics which are raised dry, is of the ordinary tempered wire, but that used for raising cloths wet or damp, is made of brass. The foundation of the clothing consists of a thin layer of rubber composition, a layer of cotton fabric and an upper layer of rubber. The usual bend of the wire, which has a needle point, is that seen in Fig. 121. Sellars made some alteration in the card-clothing used for his vertical machine. That for cross-raising was a straight wire (Fig. 122) pricked in a twill or diagonal form (Fig. 123).

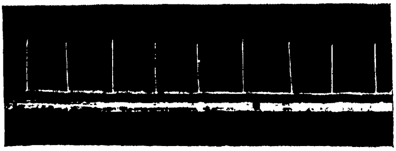


FIG. 122.

The clothing is wrapped spirally on the raising rollers (Fig. 124) the clothing on one roller being wrapped from right to left, and that on the adjacent roller from left to right. The direction of the movement of the rollers, and the method of clothing, may cause the points of the card-wire to operate on the cloth in two ways: first, the points of the wire may move through the face of the fabric in the direction of the bend, and second, in the opposite direction to the bend.

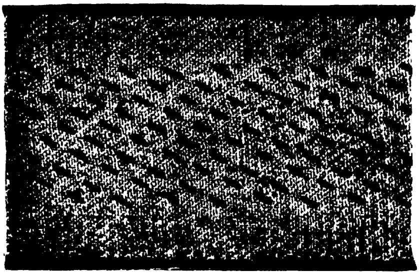


FIG. 123.

(91) *Card-wire Raising Machines.*

One of the earliest attempts at substituting card-wire for teazles was that made by J. C. Daniells of Frome, who invented a card-raising machine in 1819. The clothing was nailed on to the main cylinder in strips, taking the place of the teazle frames on the gig. Later, the cards were pricked with two heights of wire, so that the effect might be less at the commence-

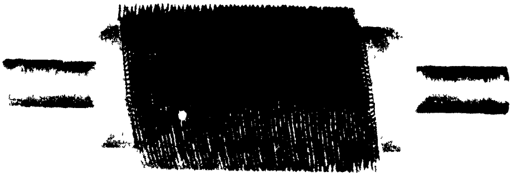


FIG. 124.

ment of raising, by fewer points being active, than when some fibre had been raised, and the piece brought into closer contact with the strips of card. The shorter wire was intended rather to comb and straighten than raise, and, for this reason, was duller at the point than the longer wire. The character and bend of the two series of teeth are shown in Fig. 125.

That the inventor found difficulty in the use of this machine is indicated by a modification which he also patented, with the strips of clothing adjustable on springs to increase their elasticity and pliability. Raising was done, as on the gig, in the direction of the warp.

Ferrabee invented a cross-raising machine in 1830, in which the strips of clothing were fixed on endless belts, traversing from list to list of the piece. This is one of the earliest machines for raising the cloth from side to side, or with the weft.

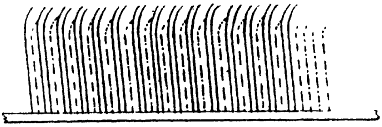


FIG. 125.

Worrall & Kershaw in 1887 endeavoured to raise equally on the warp and on the weft at one and the same process, the raising cylinder being set at an angle with the length of the cloth, so that the raising action was not parallel with one series of threads and at right angles to the other. This should give, theoretically, the fullest pile of fibre on the cloth, and hence the twofold raising which is practised in the finishing of face-cloths, namely, raising on the length of the piece and on the width in succession.

(92) *Modern Card-raising Machine.*

The types of card-raising machines are:—

(1) The vertical machine.
(2) The horizontal machine.
(3) The rotary machine.

The first type is chiefly adapted to the treatment of fabrics of the cotton blanket and rug class, and heavy cottons with a pile surface, such as fustians and moleskins. The machine is simple in construction, consisting of suitably arranged tension bars, and of a series of rollers one above the other covered with card-clothing. The pieces to be raised having been passed round adjustable stretchers or bars at the bottom of the machine, are brought in contact with the raising cylinders in succession.

An early type of the vertical machine was invented by Hampson & Marshall in 1887. It is known as the "Direct Upright". Eight rollers about four inches in diameter covered with card clothing are used, and may be run either with or against the cloth as required. They are driven by bevel gearing, and make from 300 to 400 revolutions per minute. The machine is used chiefly for hard cottons and flannelettes, not being gentle enough in action for woollens.

One of the latest inventions is that of Sellars, who endeavoured to solve several problems in raising, such as the method of standardisation by a system of adjustment of the raising parts. As the raising efficiency of the teazle deteriorates from the first to the last contact with the cloth, it could not be successfully used in experiments of this character, for it does not, like card-wire, retain its original raising point. Sellars' machine was invented and constructed to give, by means of requisite mechanical adjustments, the same raised results, by corresponding routine, on pieces of like manufacture.

The machine consists of a series of raising rollers, and of pairs of presentation rollers for maintaining the cloth at the same tension during the work. The raising rollers, fixed one above the other on each side of the machine, are hexagonal in shape, so that a straight flat portion of card-wire operates on the face of the cloth. Each section of these rollers is 2 inches across, and 54 inches in length, equal to 108 square inches of card-raising surface. These rollers are fixed in a frame which is operated by eccentrics at the bottom of the machine, and makes from 700 to 1,000 strokes per minute. The movement of the raising rollers is in the form of the letter D: if they moved straight up and down, the result would be a ruffled pile, but not combed and straightened. A feature of raising, under any condition or system, is the production of flock or loose fibre, which on both teazle and card-wire in time lessens the efficiency of the raising contact. By using hexagonal-shaped rollers, frequent and automatic changes of the card are effected. Such rollers turn intermittently, so that the used surface is regularly cleaned of fibre. This is done by the rollers coming in contact with revolving brushes, which also keep the teeth or points of the card-clothing in a satisfactory condition for raising.

The presentation rollers are positively driven, independently of the hexagonal card-raising rollers. They carry the cloth forward at a uniform speed, varying from four to ten yards per minute. Variation in this speed determines the amount of draw or draft through the cloth. Assuming the raising roller makes 700 oscillations per minute, and the cloth travels at 180 inches per minute, the raising surface would lead the cloth by 520 inches, hence in travelling past each flat, it is raised approximately four times, and if there are seven flats on each side of the machine, treated fifty-six times with even results from list to list. The accurate mechanical regulation of the relative speeds of the raising surface and of the fabric is a special feature of the machine. There are, also, means for adjusting the distance of the flats from the face of the fabric to the one-thousandth part of an inch, and this adjustment is registered on a dial, so that subsequent pieces of the same structure can be treated in exactly the same way.

Cross-raising is done by three rollers, $2\frac{1}{2}$ inches in diameter at each side of the machine, covered with a special straight wire, (Fig. 122). Such rollers travel at the same speed as the fabric, but in addition, oscillate to and fro, or from side to side of the fabric, from ·1 inch to $1\frac{1}{2}$ inches, making 400 to 500 traverses per minute, and operate on the piece immediately it leaves the top presentation roller. As these rollers travel with the piece, they are not liable to disturb the weft yarn, but give satisfactory raised results.

(93) *The Horizontal Machine.*

A simple type of horizontal machine is that used in the raising of blankets, and consists of a raising roller covered with card-clothing spirally, with smooth spaces between the strips of clothing. The cylinder revolves, and also oscillates backwards and forwards, having, in consequence, two effects in raising the fabric: first, that due to the revolving of the cylinder, and second, to the lateral traverse. As in other types of card-raising machines, a brush is used for maintaining the card-teeth in good raising condition.

Fig. 126 is a section of Tomlinson's horizontal machine. Two pairs of raising cylinders are used, and the fabric may be raised on both sides at the same time. The piece is stretched between the rollers A, A^1, and passes under the raising cylinder B, where it is treated on the upper side, over the raising cylinders C, C^1, by which it is treated on the under side, under B^1, and again raised on the upper side. The points of the card-wire, as seen on the rollers B, B^1, and C, C^1, are in opposite directions to each other. The brushes are used for cleaning the upper and lower raising rollers.

The piece drafts through the clothing of rollers B and C^1: on the other hand, the points of the card-wire of the raising rollers C and B^1 are in the same direction as the movement of the fabric, and the rollers have greater surface speed than the cloth. Two effects are thus obtained: first, the piece is drawn forcibly over the clothing of rollers B and C^1, and second, the two raising rollers C and B^1 comb through the fibre on the surface of the fabric.

The cloth first passes over guide roller A coming in contact with the wire of roller B, which imparts movement to roller C underneath the cloth, by wheel gearing; passing from this roller, it comes in contact with the clothing on C^1, which transmits motion to the raising roller B^1 operating on the upper side of the cloth, after which the piece passes over guide roller A^1 to the usual folding motion.

Another form of construction is that in which a pair of

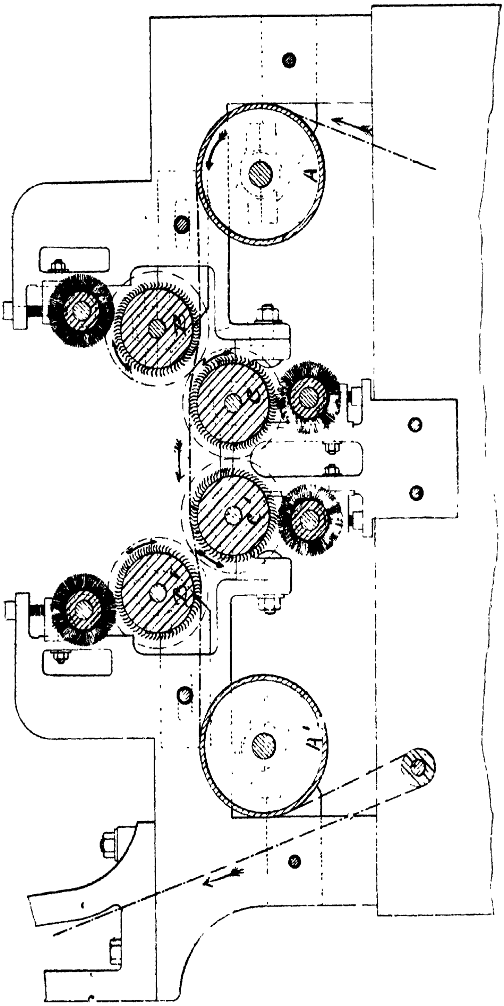


FIG. 126.

rollers is fixed in a swing or oscillating frame, which moves backwards and forwards, whilst the rollers rotate, as in the blanket raising machine. The points of the card clothing are in opposite directions on each roller.

These horizontal machines have been almost entirely superseded by those of the rotary class.

(94) *Rotary Machines.*

The principal type of card-raising machines of the rotary construction is the Moser. As originally patented in this country in 1885, there were five points of contact between the cloth and the raising rollers for each passage of the piece through the machine, with requisite tensioning parts for maintaining the fabric at the same stretch. The leading features of the machine have been retained in later improvements, but increased raising efficiency has been acquired by keeping the pieces more in contact with the card-clothed rollers, and also by other devices for the regulation and adjustment of these rollers.

Moser made a distinct advance in the use of card-wire teeth for raising, as a substitute for the teazle. One branch of cotton manufacturing has been largely developed by the use of machines of the Moser type. On one of the vertical card machines, to which reference has been made, thick, rough cotton fabrics, such as blankets and rugs, may be successfully raised: on the Moser machine, thin fabrics, such as flannelettes, may be covered with a soft pile of fibre which gives them a similar character and handle to a woollen flannel.

The horizontal and vertical machines have not had much success in the woollen trade, machines of the rotary construction having been preferred. The card-wrapped rollers on these machines are fixed in a revolving cylinder, and take the place of the teazle rods in the ordinary gig. There are many features in which the raising gig and the Moser machine differ from each other. In the single gig, the cylinder travels in the opposite direction to the fabric: in the Moser, the card rollers are driven independently of the cylinder, and may be made to operate on the cloth in two ways, which gives increased possibilities as to diversity of raising effect.

There are two important classes of these machines, known as single- and double-action, respectively. In the former, the raising rollers and the cloth move in the same direction, the rollers having the higher superficial speed, but the cylinder moves in the opposite direction. In the double-action machine the cylinder travels with the cloth, but alternate rollers revolve at different speeds in the opposite direction.

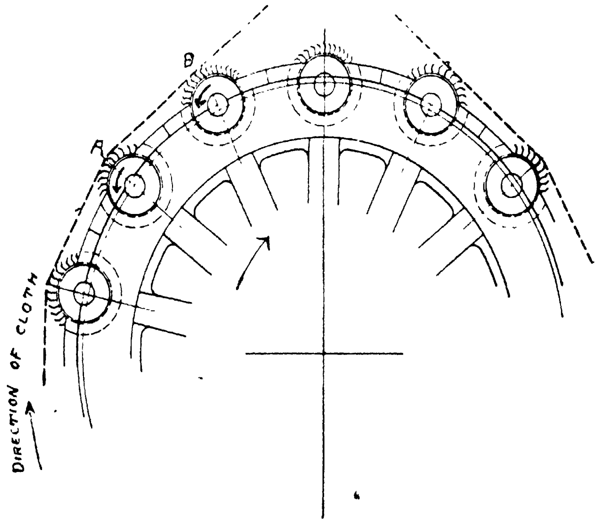


FIG. 127.—Cylinder of Raising Machine.

Fig. 127 shows the positions of the card rollers in relation to each other in the double-action machine: rollers A and B revolve against the fabric, series A using the points of the wire, and series B the back of the wire. Rollers A are, therefore, primarily retainers, or resist the forward movement of the cloth (the piece drafting through the teeth of the clothing), bringing the fibre on to the face, whilst rollers B comb and lay the fibre. A change in the relative speeds of the two series may cause series A to have an increased raising effect.

The "moss" finish, a somewhat rough and irregular pile, is obtained by running the cylinder the reverse way of the piece, with all the rollers moving with the piece, and using the points of the teeth, which has the effect of disturbing the fibre and producing the rough characteristic named.

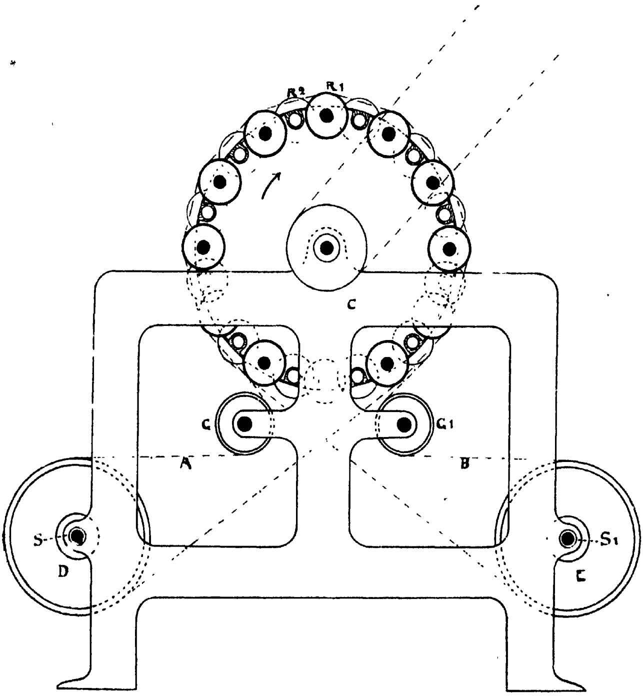


Fig. 128.

Figs. 128 and 129 are the two opposite ends of one type of a 24-roller Tomlinson machine: a later construction is shown in Figs. 130 and 131. The two series of rollers, R^1, and R^2, are driven by belts A and B passing round pulleys D and E, and guides G and G^1.

The speed of the rollers may be varied by using step or cone pulleys. The shaft of the cylinder carries a toothed wheel, gearing with the wheels on the shafts of the upper cone pulleys P, P^2 (Fig. 129). Straps pass round these pulleys and the cone pulleys P^1 and P^3. The speed of the cylinder is constant but that of the raising rollers, by the use of cone pulleys, is variable.

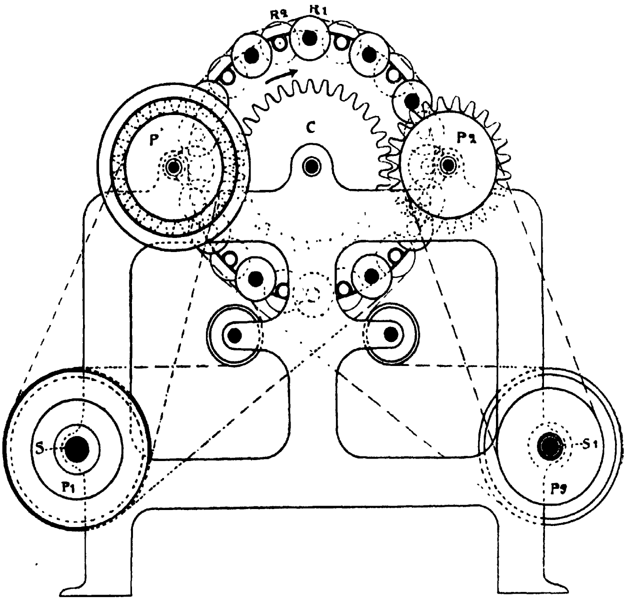


FIG. 129.

(95) *Routine of the Piece.*

This is shown in Figs. 130 and 131, a 14-roller machine for felt nap raising. The teeth of the card-clothing of each roller are in the same direction.

The piece from the cuttling section A, passes over the tension guide B, under C, round D and tensioning roller 1, under roller 2, and over the cylinder to tension roller 2A, over top roller 3 and the head of the machine to the folding motion.

The method of driving is also indicated. On the main cylinder is the driving pulley, from which all other motions

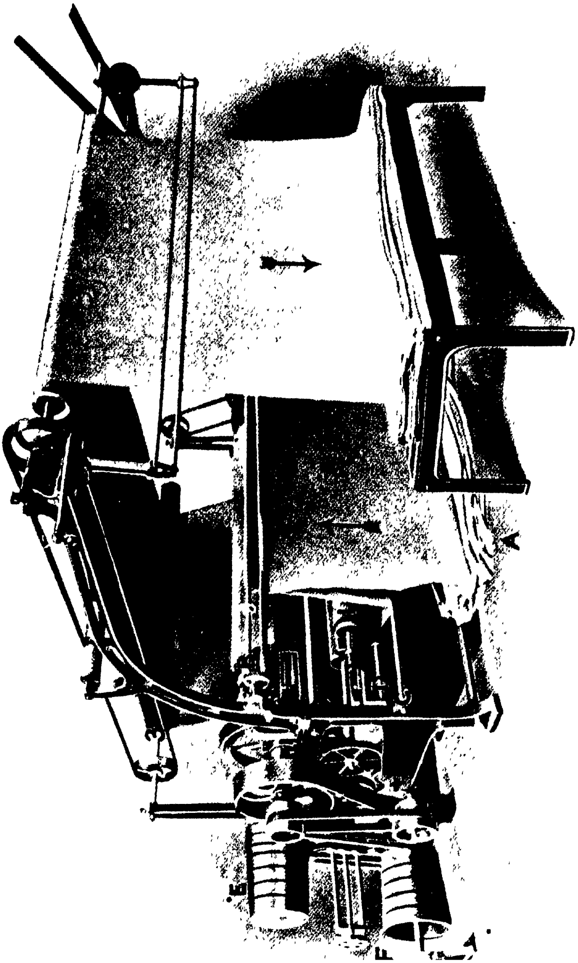


Fig. 130.—Tomlinson's Card-Raising Machine.

are derived. On the cylinder shaft is fixed a belt pulley which drives a pulley on the stud, which carries cone pulley F. From

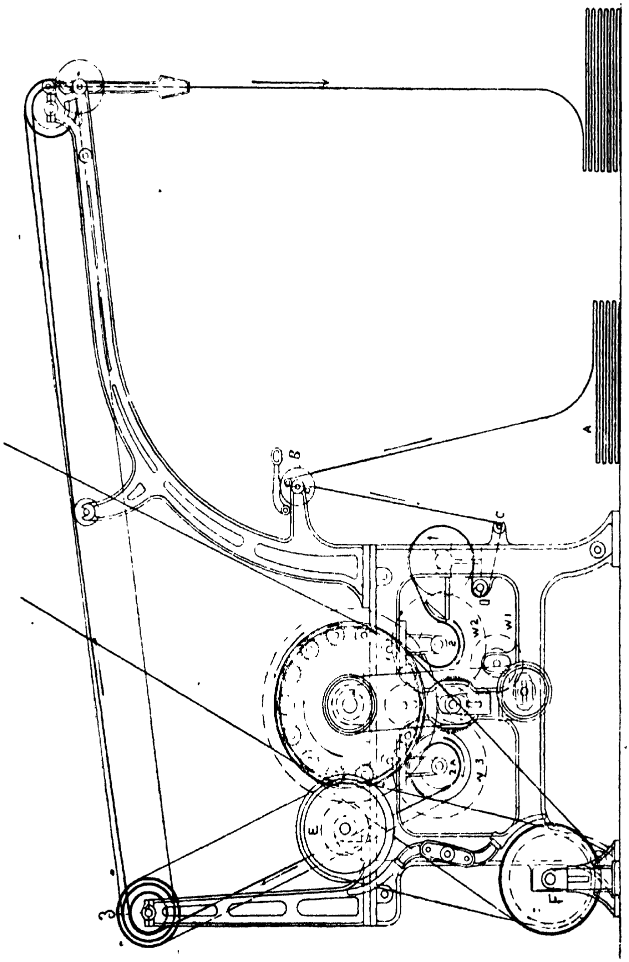


FIG. 131.

this cone pulley motion is imparted to the upper cone pulley E. On the shaft carrying the latter pulley is a toothed wheel at each end of the cylinder, which gears into the large wheels running loose on the cylinder shaft. These wheels each carry an arm to which are secured the ends of the belts which encircle the pulleys on the ends of the card-raising rollers, which are thus made to revolve in the reverse direction to the cylinder. A belt passes round the cone pulley on the main shaft and the pulley mounted on a stud in the centre of the frame, at the bottom of the machine. This pulley carries a pinion, which by wheel gearing, W^1, W^2, W^3, gives motion to the strap pulley 3, fixed on the top roller for conveying the fabric forward. In this way a definite length of cloth is carried to the cylinder, and a corresponding length of cloth is positively removed, under uniform tension. By means of this cone arrangement, the requisite changing speeds imparted to the movement of the cloth, can also be made readily to the rollers for conveying the cloth to the folding motion.

(96) *Brushing and Steaming.*

This is done on the Brushing Mill (Fig. 132) which may be either single or double in action, that is, have one or two brushes. The ordinary machine is simple in construction, consisting of the steam box A, the revolving brushes B^1 and B^2, and of the folding motion. The piece passes over the steam box from the cuttling board, then between guide rollers, over brush B^1, over central guide roller, and brush B^2, under back guide roller, and over the top guide rollers to the folding motion. Steaming softens the fabric, so that the action of the brushes is more effective. Brushing is done in worsteds to prepare for cutting, and has a similar effect to raising a woollen cloth, but is of a milder character. After the final pressing, the cloths are also steamed and brushed, to further dress the surface of the fabric, as well as to remove any excessive glaze or unnatural quality of lustre.

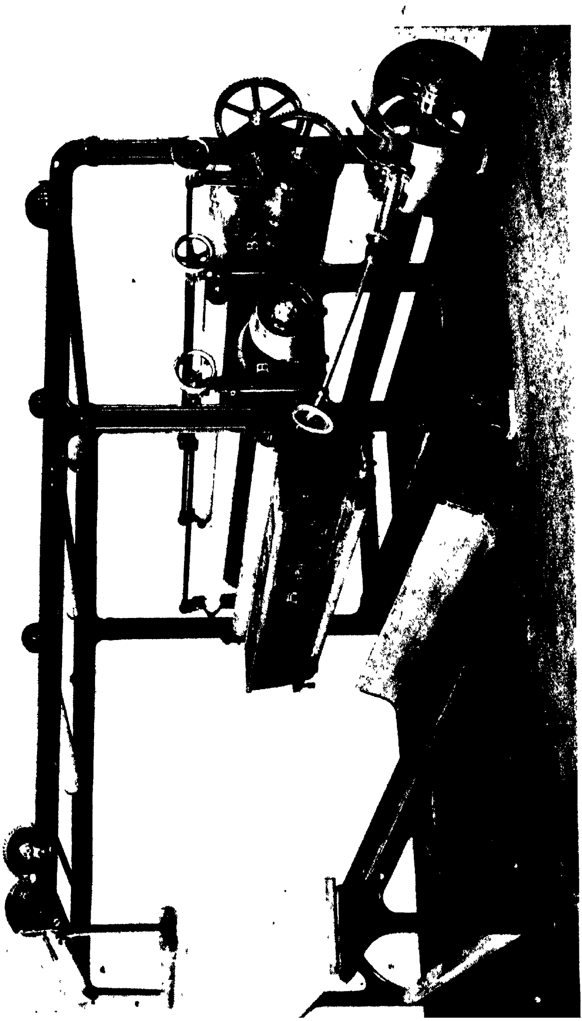


FIG. 132.—Whiteley's Brushing Mill.

CHAPTER X.

CUTTING, CROPPING, OR SHEARING.

(97) Cropping. (98) The Effects of Cutting. (99) Cutting Machines. (100) The Cross-cutting Machine. (101) The Continuous Cutting Machine. (102) Setting of the Cutting Parts. (103) Form of the Bar or "Bed" under the Cutters. (104) Machines with Two or More Cylinders. (105) Grinding.

(97) *Cropping.*

BEFORE the invention of the Cross-cutting Machine—the earliest form of cutting machine—the pieces were sheared by hand, (Fig. 133) being stretched in successive lengths in a suitable frame, when the croppers with their shears operated from end to end and side to side of each length. The two terms "shearing" and "cropping" originated from the huge hand-shears A (Fig. 133), used in this work, and the designation applied to the operatives engaged therein, namely, that of "croppers". These terms have ceased to have the same meaning which in the old days they conveyed.

To cut, or "crop," as it was significantly termed, the surface of a fine woven and well-raised piece, was a skilful performance. How it was successfully accomplished with the instruments used, it is not easy to apprehend: but the face-cloths treated in this manual way, prove the cropper to have been a capable operative. No wonder that he should have formed a remnant of the textile workers who opposed, to the bitter end, the use of automatic machinery in substitution of manual dexterity.

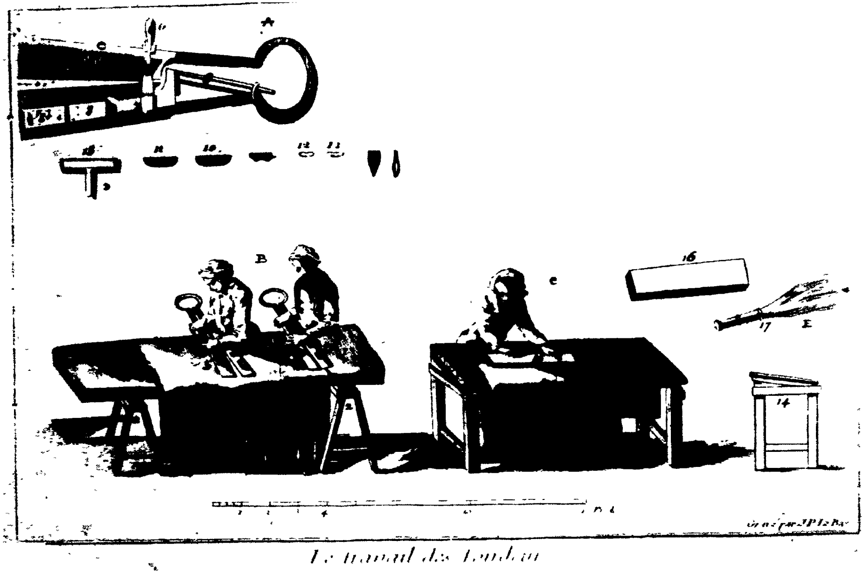


Fig. 133.—A reproduction of a wood engraving from an old French work.
A. Hand shears mounted as used. B. Croppers at work. C. Operative hand raising. D. Hand raiser.
E. Whisk for brushing the cloth.

(98) *The Effects of Cutting.*

Cutting or cropping is a purely mechanical operation, and has only a "machine" effect upon the face or back of the cloth. It is, however, an operation done to obtain several distinct effects varying with the structure and quality of the fabric, the materials used in its manufacture, and the style of finish wanted. For example, it may be practised to even or level a raised pile of fibre, to impart colour and weave definition, as in clear-finished Saxonies or Botany worsteds, or to brighten and give smartness to an ordinary Cheviot suiting or costume.

To understand more fully the nature of the work, it may be considered in relation to the effects it produces on Cheviots, fine woollens with a clear or soft finish, Crossbred and Botany worsteds, also velvet-pile rugs, meltons, doeskins and beavers.

Cheviots, Flannels, etc.—These cloths are only slightly cut. The natural handle of the fabrics should be retained, which would not be the case if they were cut clear or smart. This particularly applies to Cheviot fabrics where crispness of handle should be a feature, so that a certain amount of surface fibre is essential. Moreover, such fabrics are not suitable for a close-cut operation, as the threads would become too bare and distinct, and the patterns too well defined.

Clear-faced Woollens.—The clear-cutting of woollens is applied to twist-warp fabrics of the whipcord and buckskin type, and also to well-felted double-plain fabrics. The cloths have quite different qualities to the Cheviot, being made of different materials and undergoing a routine of finish which makes a close texture. At the same time the fabrics, in some instances, are more firmly woven than a Cheviot. Clear-cutting, therefore, brings out the characteristics of such cloths when finished, namely, smartness of definition of pattern, whether due to colour, weave or both.

Soft-finished Woollens.—In these fabrics, closeness of cutting would not be an advantage, because the softness or kindness of handle is a special quality of woollens of this class. The cloths are not milled to the same extent as in a clear-cut finish, but left more elastic or supple. To remove all surface fibre would have a somewhat similar effect to clear-cutting on a Cheviot.

Botany Worsteds.—These are treated according to the quality of the yarns, and the style of finish. In Botany fabrics the finish may be either milled or unmilled, each being differently treated in cutting. A smart, clear surface is one in which cutting is done almost as closely as possible, removing all surface fibre from the threads, so that weave, design and colour-effect are well defined. On the other hand, in a milled finish, the face of the fabric is not cut so clear, and the fibre left on the surface improves its handle.

Crossbred Worsteds.—These are usually clear cut, though there is considerable difference as to the degree of closeness. When in Crossbreds, shrinkage is practised, it is not usual, as in milled Botany worsteds, to cut clear.

Pile Cloths.—First, in which there is a vertical pile, as in rugs and velvet-finished cloths, where, if cutting is done, it is only to top or level the fibres. Second, in meltons, where close-cutting is not required, as it would make the surface of the fabric too bare, reducing the wearing quality. Third, in dress-face fabrics, cutting has to be very carefully done, with the object of getting an even pile, short, but not too close, as the lustre and density of the pile are important qualities of the finish.

The consideration of these cloths makes it evident that though a mechanical work, "cutting" must be practised with judgment, and with regard to the quality and character of the fabrics treated. Minute and frequent adjustment of the cutting parts is an essential of good work in the running of the machine.

The fabric should be examined after each operation, care being exercised that it is not sheared too "close". This, in any quality or make of cloth, tends to impair the fulness of handle and also to diminish the wearing quality. By removing such a quantity of fibre as to leave the threads of warp and weft too distinct, a fabric is produced, which, in the made-up garment, soon becomes shiny and unsatisfactory. Whether a Cheviot or a Crossbred fabric, in which shearing should have but a "topping" effect; or a dress-face woollen, in which it should produce a perfectly even pile of fibres; or in a fine worsted, where the idea is to acquire clearness of weave and colour pattern, cutting should not be continued until the texture suffers in softness and quality.

(99) *Cutting Machines.*

The two types of cutting machines are the "Cross-cut," and the "Perpetual". The cutting parts of the former (Fig. 134) operate from selvedge to selvedge of the piece, and of the latter (Fig. 135) from end to end. As already stated, the Cross-cut is the original construction of machine. Though not now used to any considerable extent, it has still a useful place in a plant of finishing machinery. To obtain the smartest effect by cutting, either on a fine woollen or worsted, both the cross-cut and the continuous method of cutting may be practised. That, generally, only the latter is done, is chiefly on account of economy of routine, Cross-cutting being a longer operation than cutting on the Perpetual.

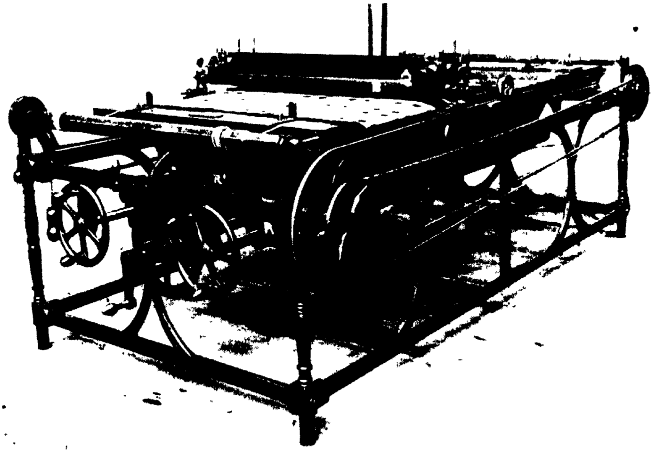


FIG. 134.—Cross-Cutting Machine.

In figured or spotted designs, in which tne effect is due to the weft (*e.g.*, vestings and certain classes of dress and mantle cloths), it is useful to cut in a line with the weft yarn. Should the fabric have a warp or weft face, a "clear" cut is better obtained by practising both systems. The same also applies when the warp and weft yarns are equally on the upper side of the fabric. Reverting, for example, to the texture illustrated in Fig. 90, in cutting such a fabric on the Continuous machine, a portion of the extraneous fibre would be only partially affected. Filament betwixt the warp threads would be more evenly shortened or removed—according to the closeness of the cut—by also treating the piece on the Cross-cutting machine. Still, it should be observed that in the ordinary classes of fancy and wool-dye woollens, and of fancy and piece-dye worsteds, the Continuous machine is, in practice, the one chiefly used.

(100) *The Cross-cutting Machine.*

This consists of the frame in which the piece is stretched in lengths, passing from one piece roller R to another roller R^1 (Fig. 134). The cloth is carried over a flexible bed, above which are fixed the cutting parts A. These all operate in a carriage B, which runs across the machine, or from list to list of the piece, cutting taking place at the same time. On reaching the opposite side of the machine to the starting-point, the cylinder is automatically put out of gear, and may then, with the other cutting parts, be readily drawn back by the operative to the normal or starting position. If the length of cloth treated is satisfactory, it is wound from the starting to the finishing roller. By this means, the same stretch of fabric may be operated upon as many times as required.

(101) *Continuous-cutting Machine.*

A view of this machine is given in Fig. 135, and two end elevations in Figs. 136 and 137. (The letters in the illustrations indicate corresponding parts.) The method of driving is shown in Fig. 136 and the routine of the piece in Fig. 137. The driving

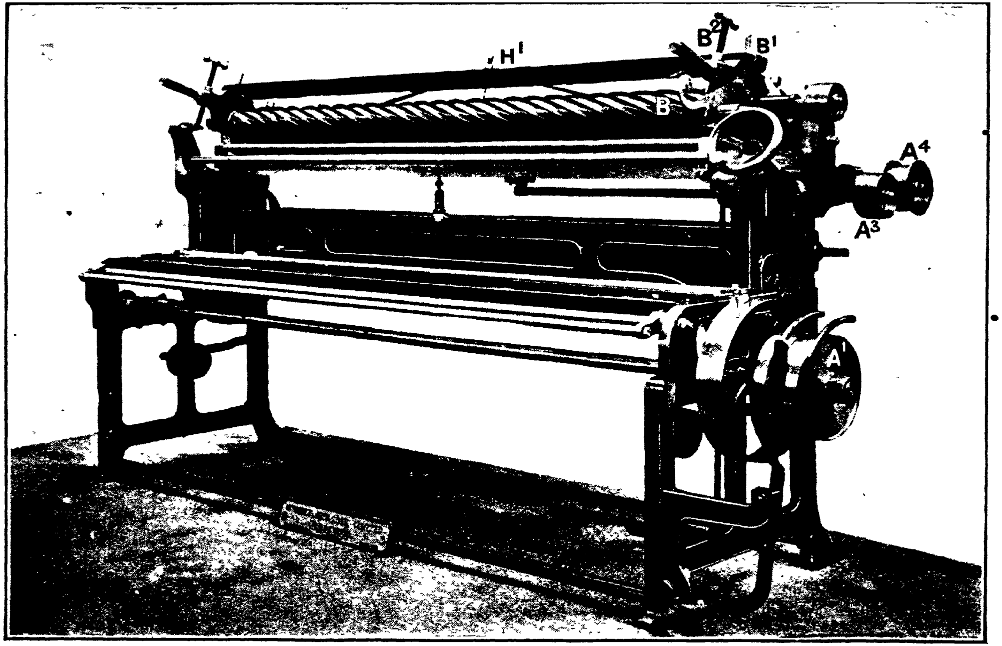


Fig. 135.—Whiteley's Perpetual, or Continuous Cutting Machine.

is effected by belt round A^1. First, motion is given by A^2 to the cylinder B, by strap passing round pulleys A^3 and A^4, enabling

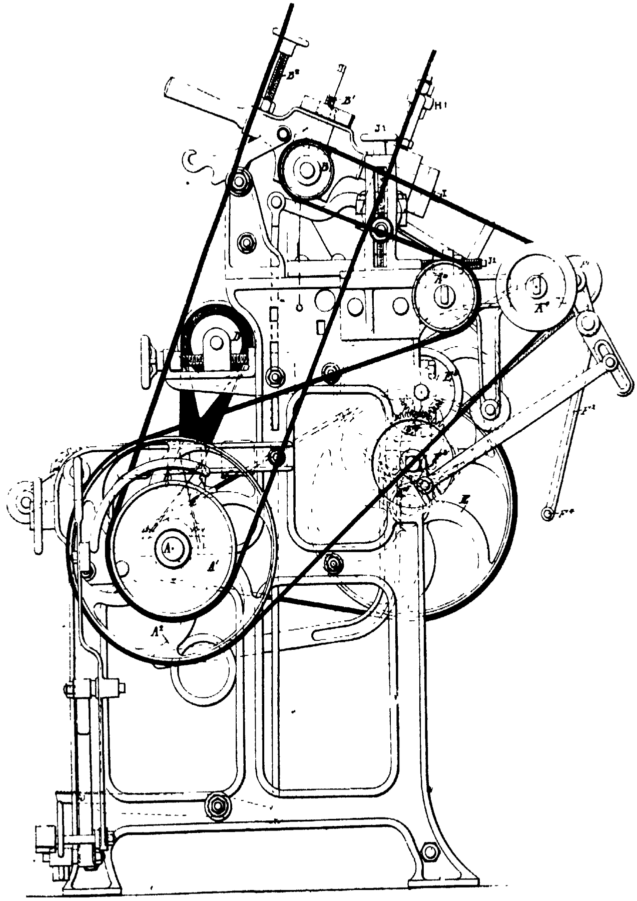


FIG. 136.

the operative to raise the cylinder and cutting parts, from the face of the cloth, and prevent accidents or damage to the piece. Should there be any knot, snarl, or irregular place from whatever cause, by this system of cylinder drive the cutting or cropping mechanism can be put out of action, and yet the piece continue to travel forward.

The remaining parts, namely, the fan, the brush, the draw roller, and the folding motion, Fig. 137, are operated as follows:

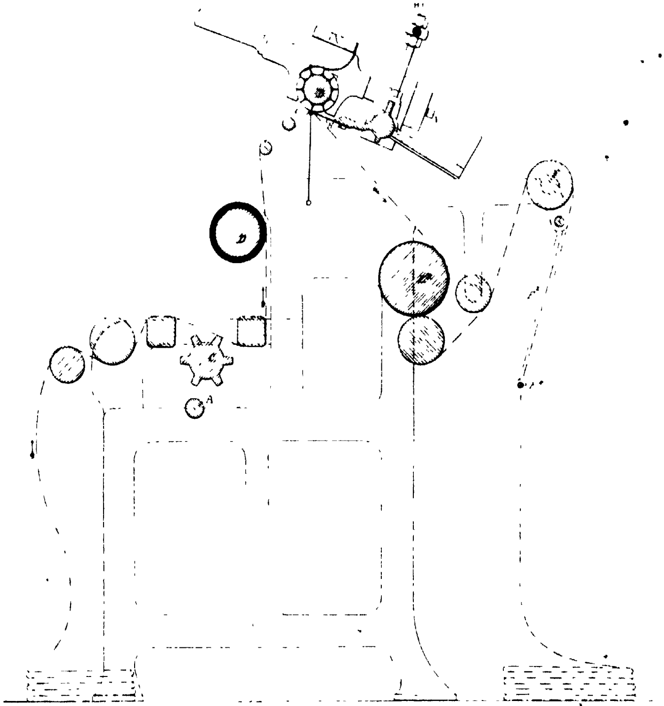


Fig. 137.

The fan C is driven by open belt passing round pulley on shaft A; and the brush D, by a cross belt passing round a pulley on the same shaft. The wheel on the shaft of the draw roller E^2 (Fig. 136) is driven by E^1. On the shaft of this roller is a pulley E^3, and a band passing round it and the pulley F^1, drives the feeding roller F of the folding motion. On the shaft of E^3 is a pinion E^4, gearing with the wheel mounted with crank F^3, which, by lever connections, gives motion to the folding arm F^2, carrying the cuttler bar F^4.

Routine of the Piece.—This is shown in Fig. 137. It is clearly indicated how the piece travels through the machine to the folding motion. First, round guide rollers, between tension bars to supplementary fixed guides, over the "bed" or surface G, to the draw or drag roller E^2, and thence to the folding motion. The degree of tension applied to the fabric can be regulated. The beater or fan C is useful in loosening the fibre on the surface of the fabric. The brush D further prepares the texture for the cutting or cropping operation. Sometimes an emery roller is used in place of the brush, and has a more severe action. The degree of tension on the piece is modified, in the first place, by a number of fixed, smooth bars and guide rollers, over and under which the piece passes; and second, by the draw or drag on the piece by roller E^2 and the roller beneath it, which are kept in contact with each other by weighted lever.

Too much importance cannot be placed on maintaining the cloth at one uniform tension, not only from end to end, but from list to list. Successful work is dependent upon this, as upon the efficiency of the cutting parts. Adjustment and attention to both are essential.

(102) *Setting of the Cutting Parts.*

This is all-important in the treatment of worsted and fine woollen fabrics of every grade. Should the cylinder not be truly set, that is, level in relation to the lower cutting blade, there will be unevenness of result, very difficult to overcome. It is, of course, understood that any inequality in the cutting efficiency of the lower blade, in the bed or surface over which the piece passes, or in the setting and grinding of the spiral blades of the cylinder, will cause defective work.

For the cylinder, there are several points of adjustment. These are seen in Figs. 135 to 138, the latter being a view of the cutting parts placed in a vertical position, or removed from the cloth. It is necessary to be able (1) to adjust the cylinder in relation to the blade; and (2) the cylinder and the blade as regards closeness of contact with the piece. Screw B^2 lowers both the cylinder and the blade on to the

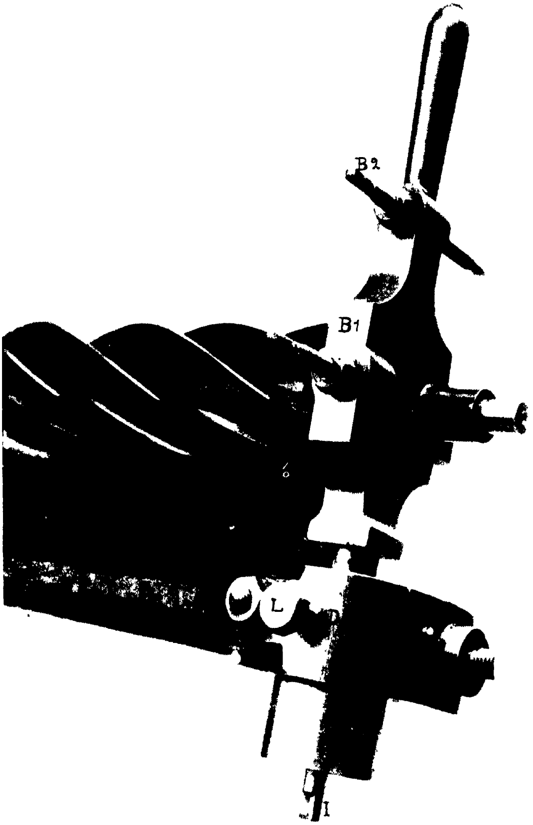


Fig. 138.

piece, increasing the severity of the cutting process. Sometimes in practice, instead of altering the screw, small, thin metal pieces are placed under the bottom of the screw. To get a cleaner cut, by bringing the cutting parts into closer contact with each other, screw B^1 is altered. For pressing the cylinder forward or backward, screw I is used. Before this screw can be turned, the lock nut L on the bracket D must be released. There are duplicate parts at the opposite end of the machine. Providing, as may happen in working, the lower blade should not be so true in the centre as at the ends, an adjustment may be made by screw H^1, which is placed on the stay of the bed of the lower blade. The entire headstock of the machine may be lowered or highered by screw J^1, and moved nearer to, or further from the bed over which the piece passes, by screw J^2. This screw system of altering the parts makes the minutest changes possible, yet permanent to the parts *affected.*

(103) *Form of the Bar, or "Bed," under the Cutters.*

The surface over which the piece passes in cutting may be rigid or flexible. This surface, or "bed," as it is technically termed, is illustrated in Fig. 139 in different forms, solid as in A and E, spring as in B, and hollow as in C and D. In the woollen and worsted trades the solid type A, and spring type B, are generally used, these being more suitable for fine and true cutting, but they necessitate that the lower blade should be evenly set. The spring type is necessarily more yielding, and adapted for fabrics which are not cut so close.

Fig. 140 is the form of bed patented by Martin. As is shown, it consists of two parts B and C, secured to each other, leaving a space of a fraction of an inch through which is passed a glazed texture. The upper and lower portions of this texture are looped, a rubber tube H being inserted in the former, and an iron rod or weight J in the latter: the remaining parts are similar to those in the ordinary "Cutter". The object of this improvement is to have a more elastic surface for the piece to pass over, so that any knots would sink into the bed, and so prevent holes being made by cutting.

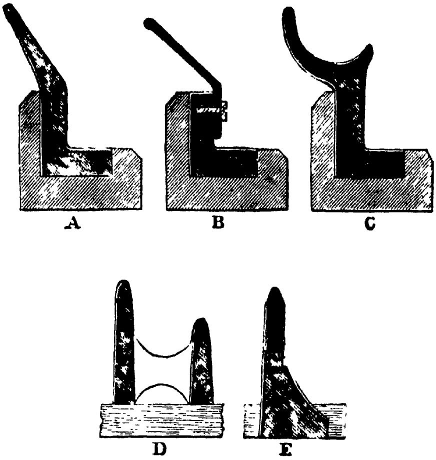


FIG. 139.

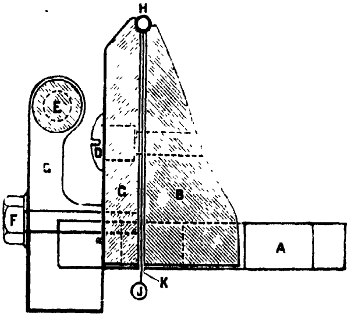


FIG. 140.

Whatever the form of the bed, it should present an even surface to the cutting blade. Any inequality in the slightest degree will cause irregular shearing.

(104) *Machines with Two or More Cylinders.*

Machines of this type are constructed with two, three or four sets of cutting parts. They are chiefly employed in the finishing of stuff fabrics and certain classes of linens. The idea is to complete the process at one passage through the machine, securing as many as four successive croppings at one operation. This work in a single machine would necessitate the piece being treated four times. It is, therefore, an economical system on the classes of fabrics named, but is not adapted for the ordinary classes of woollens and worsteds. A more gradual removal of the surface fibre, and acquirement of the requisite closeness of contact of the cutting parts with the piece—adjusted as found desirable after each cut—gives in these cloths a more satisfactory effect.

Another feature to be noted in the use of compound machines on woollens and worsteds is that any fault in the yarns, such as knots or slubs, would be likely to produce more serious damage before being discovered than in the single cutter.

Fig. 141 is an illustration of a three-cylinder machine. The method of driving the cylinders C, C^1, C^2, is shown, and is similar to that in a single machine. The first cylinder may be raised off the bed in the usual way, and the second and third cylinders by levers H^1 and H^2. There are tensioning bars, brush, and guide roller in front of each set of cutting parts, the piece being tensioned as in a single machine, as it passes forward to each bed, which may be hollow, spring, or solid. The first two brushes run against the piece, and the third with the piece. The first cylinder is for rough cutting, the second for the intermediate cut, and the third for the finishing cut. One advantage of the compound machine is great economy in time. In such a three-cylinder machine, the piece may be cut at a speed of 15 to 20 yards per minute.

(105) *Grinding.*

This is not an actual finishing operation but concerns the keeping in good working condition the spiral blades of the cylinder, and of the lower or fixed blade. The work is performed

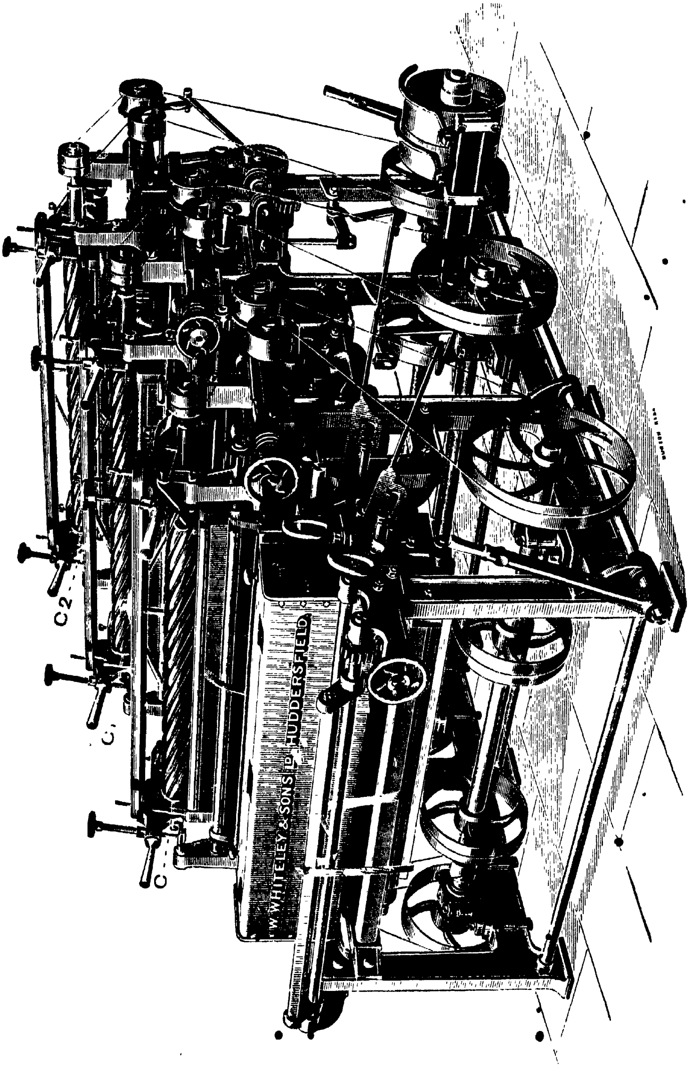


Fig. 141.—Triple Continuous Cutting Machine.

in the grinding frame. Three frames may be used for convenience and economy, namely, Fig. 142, a second frame in which the iron roller for grinding the lower blade is fixed, and a third frame in which the cylinder runs in contact with the lower blade, and in the reverse direction to that when cutting. As a rule, in the factory only one frame, that illustrated, is used, so that the process of grinding, which includes the three parts named, is done on this machine.

The machine consists of suitable bearings for the cylinder, and framing for fixing the lower blade when running in contact with roller R; of the carriage C, in which the strickle S is mounted, and of chain gear drive D, and also of reversing motion for the carriage. The strickle has a rough surface, about two inches across and twelve inches long, composed of a mixture of emery and glue. It is fixed by screw adjustment in contact with the spirals. When the machine is in action, the cylinder makes some 600 revolutions per minute. The strickle is carried from A to B, and a few inches beyond each point, the grinding and sharpening of the blades being effected during the forward and backward traverse of the carriage.

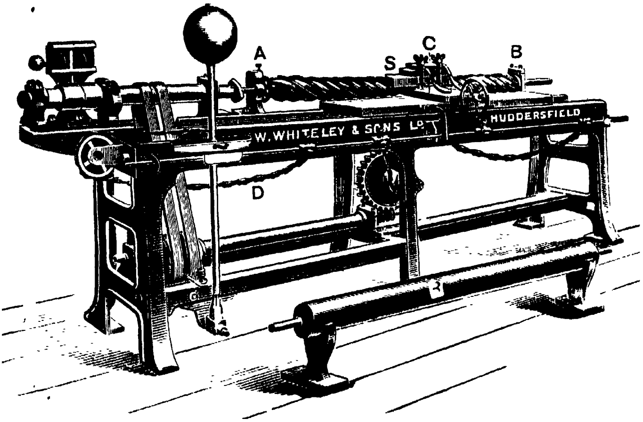


Fig. 142.

To grind the lower blade it is fixed in bearings on the framework of the machine, and has a sliding movement to and fro. It is placed in contact with roller R, also fixed on the frame, and running at a high speed. For trueing the blade after grinding, it is run with the spiral cylinder, the latter, as stated, revolving in a reverse direction to that necessary in cutting. In the first of these operations, oil and fine emery are applied, and in the second, oil only.

CHAPTER XI.

LUSTRING PROCESSES AND MACHINERY.

(106) The Production of Lustre on Woollen and Worsted Fabrics. (107) Steaming and Cooling Machines. (108) Pressing. (109) The Vertical Press. (110) The Rotary Press. (111) Intermittent Pressing Machine.

(106) *The Production of Lustre on Woollen and Worsted Fabrics.*

In certain classes of woollen and worsted textures, the production of lustre or brightness is an essential of the finishing routine, but this quality should not be obtained to the detriment of the handle of the cloth, nor should it be of a fugitive nature. It is, of course, known, from the simple manual work of ironing, that heat and pressure impart brightness and evenness to a woven surface. The application of these develop and fix the lustre on a sateen lining, but in woollen and worsted finishing, heat and pressure are only two of the causes which produce a smooth, level, bright texture.

Lustre is obtained in finishing by the following:—

(1) Boiling, (2) Blowing with steam, (3) Steaming and boiling, (4) Blowing with steam and exhausting or cooling, (5) Hot Pressing.

Methods 1, 2, 3, and 4 are of a similar nature, but vary as to the degree of lustre they impart. Each method, with its application, requires to be considered separately.

The Process of Boiling.—This is the oldest process of producing a permanent lustre on a fine woollen fabric. Doeskins, beavers, and other dress-face cloths, are submitted to this operation. It is not applicable, in the same degree, to "face" cloths in which fancy colours are used in the warp and weft. A typical doeskin is boiled for several hours both before and after dyeing, a process which would tender the fabric if not made of a sound quality of wool. Thus, a doeskin piece, after the first raising routine, is tightly wound on a smooth wooden roller tail-end first, boiled for the requisite period of time, allowed to cool, and then rewound head-end first, and reboiled. Repeated raising, boiling, and cooling follow until the correct quality of brightness has been obtained. All conditions are induced likely to bring out the lustrous quality of the fibres. Curliness or waviness is eliminated. The fibres are spread on the face of the cloth, and are in a state of compression, due to the tension applied in winding the piece on the boiling roller, when subjected to the boiling process.

Blowing with Steam.—This is a simple process for levelling the face of the fabric, and also for developing some lustre. It consists in wrapping the piece on a perforated roller with a cotton wrapper, with the face of the cloth to the wrapper. It is done on the winding-on frame, which has an ordinary roller on to which the piece is wound, with the wrapper in the first instance, and then rewound, well tensioned on to a perforated roller, with several rounds of wrapper both at the beginning and the end of running on to this roller. The ends of the wrapper are secured, and steam is blown through the piece either in the frame and revolving, or fixed vertically on a steam kettle. Cooling follows, and rewinding from the opposite end of the piece, repeating the process of blowing.

It is useful prior to scouring fabrics made of Crossbred or other yarns which might be creased in scouring, and in piece-dye fabrics before dyeing.

Steaming and Boiling.—It should produce an even fabric free from creases. Crabbing is a process of mild boiling and steaming used in the finishing of worsted fabrics. The routine consists, briefly, in winding the piece face down, with a cotton wrapper, on a roller, and boiling for a short time, then rewinding on to a perforated roller, where it is blown with steam, allowed to cool, and the operation repeated from the opposite end of the piece.

Steaming and Cooling.—This is a compound process, and consists in blowing the pieces with steam, when tightly wound with a cotton wrapper, on a perforated zinc or copper roller. In this condition, cool air is forcibly drawn for some minutes, by means of a pump, from the outer to the inner round of the piece.

A number of yards of canvas or coarse fabric are first wound on to the roller, and then a length of steaming wrapper (well-woven cotton cloth with a smooth face), the operation being completed by running the cloth and the wrapper together on to the roller. This done, a few more rounds of wrapper are applied, and then the ends secured, as in the process of steaming and blowing already described; but here the roller revolves in the horizontal position, as seen in Fig. 143. The process of cooling takes place after blowing, the pump being used for this purpose after turning off the steam supply. In a short time the condensed steam is discharged, and the piece left in a cool and natural condition.

By another system, common in Germany, the piece, after being wound on the perforated roller, is passed into a horizontally fixed cylinder, which is then closed at the ends. Steam is forced through the successive rounds of the piece from the outside to the inside, the condensed steam passing away from the interior of the roller. The process is repeated from the reverse end of the fabric, and the piece again steamed. A pump is also used for cooling and conditioning the piece.

The English system leaves the cloth in a good condition as to handle and brightness. It does not produce an artificial gloss, or an effect which is imparted to the fabric, rather than a quality which it possesses and which is developed by the finishing operation. The theory of the English system may be described. In the first place, there is the winding of the piece, well tensioned, and in contact with a strong cotton texture, on to the perforated roller. This stretching and compressing produces evenness of surface. No creases or marks, or faults due to irregularities in tension either on the warp or weft of the piece, should be possible; in the second place, when the piece is in this condition, steam, at a pressure of 40 or more lb. to the square inch, is forced

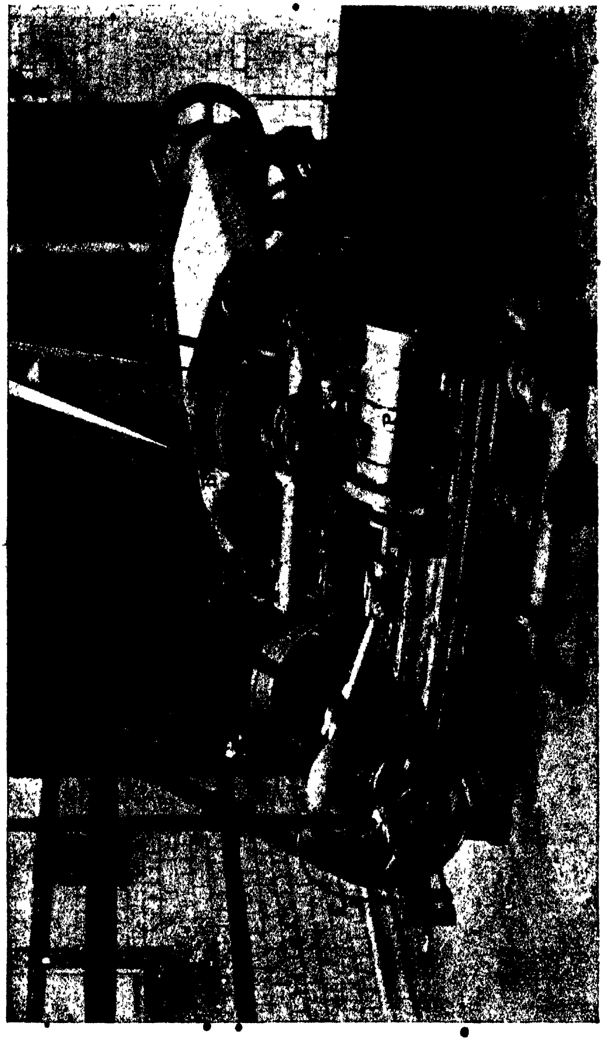


Fig. 143.—Bailey's Steaming and Cooling Machine.

through the fabric, every interstice between fibres and threads being affected, and both the materials and yarns softened and brightened; in the third place, there is the cooling process, which gives condition and quality to the cloth. This system of producing lustre is applicable to all classes of worsteds, piece-dyes and fancy fabrics, and also, according to the finish required, to ordinary Saxony and Cheviot cloths.

(107) *Steaming and Cooling Machines.*

The usual form of these machines is that illustrated in Figs. 143 and 144. It consists of two perforated rollers B B¹, pump P, and smooth wooden roller and trough for boiling. The perforated zinc or copper rollers are six inches in diameter, and have friction brakes attached for varying the tension on the wrapper and piece, when winding from one roller to the other. On each perforated roller are four yards of canvas, which are a protection to the piece when the steam is first turned on, absorbing any condensed moisture.

In actual working, ten yards of cotton wrapper are first run on to the roller on which the piece is to be wound. The piece is then taken between brake guides A, A¹, (the angle of which may be altered to give the necessary tension) and run, with the wrapper, on to roller B¹. This done, a number of yards of cotton wrapper are added, and the ends tied. The piece and the wrapper should be as near the same tension as possible; in winding on, the higher the tension, the greater the lustre developed.

In applying the steam, it is important that the condensed moisture should first be removed. This is done by opening the valve of the perforated steam feed pipe which runs from end to end inside the perforated roller, with the pump also acting for a short time. The outlet valve is then closed, a small escape valve slightly opened, and the steam allowed to circulate through the piece. In this manner the piece is evenly steamed, the process being as effective at the end farthest from, as at the end nearest to, the surface of the roller. After steaming for a few minutes, the steam supply is cut off, and the large valve at

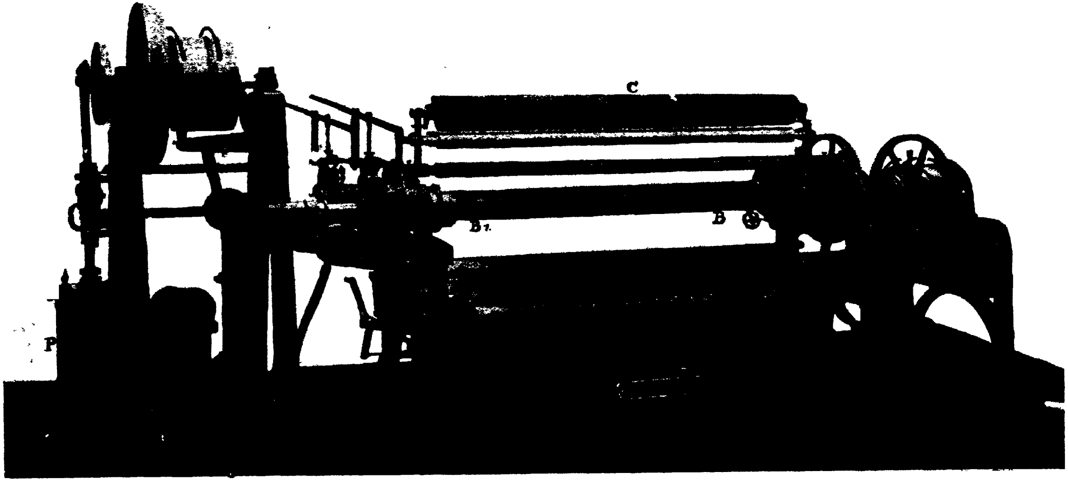


Fig. 144.—Whiteley's Steaming and Cooling Machine.

the end of the perforated roller opened. The pump is also set in motion, drawing air from the outside to the inside of the roller, rapidly cooling and conditioning the cloth. The piece and the wrapper are then taken over roller C, and wound on to roller B, and the process of steaming and cooling repeated. The advantage of the two perforated rollers is, that while one piece is being delivered from the underside of roller B^1, a second piece and the wrapper are passing over roller C to roller B.

(108) *Pressing.*

There are three distinct systems of pressing: (1) in the hydraulic vertical press (Figs. 145 and 146); (2) in the rotary press (Figs. 147 and 148); and (3) in the intermittent machine (Fig. 149), in which the pieces are pressed in yard lengths.

They differ from each other in essential principles. In the vertical press, the entire piece is pressed when folded or cuttled with press papers at one time, the fabric being in contact with heated paper surfaces; whereas in the continuous machine the pressing takes place in lengths of fabric, either in passing round a heated metal roller, or between flat metal plates. The movement of the piece is constant in the rotary press, but intermittent in the Nussey and Leachman machine.

There is a difference in the result, both as to the handle and lustre given to the texture, by pressing the piece for several hours in contact with smooth card-boards, in which condition heat is imparted by electricity or by hot plates, and by pressing the piece for a brief period between heated metal surfaces; but each system has advantages, which will be indicated.

(109) *The Vertical Press.*

Fig. 145 shows a front and end elevation of the vertical press. It consists of an upper and lower fixed flat metal piece, secured together by four iron pillars. Underneath A, and passing through it, are one or two rams or cylinders carrying the piece table D. The prepared pieces are placed on the table, filling the space between D and B, and then the table is raised by hydraulic pressure.

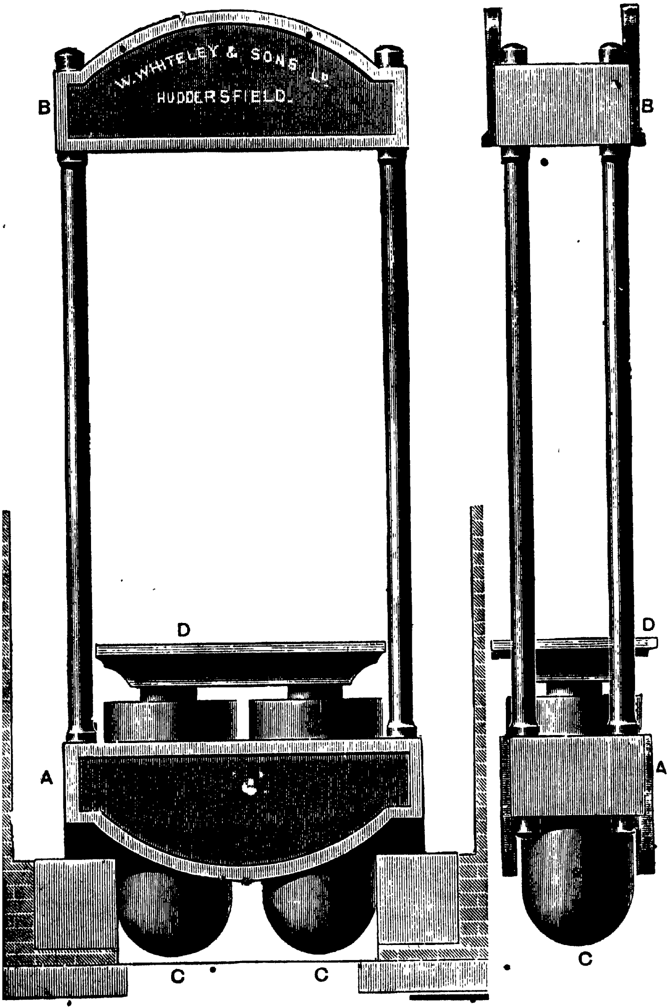


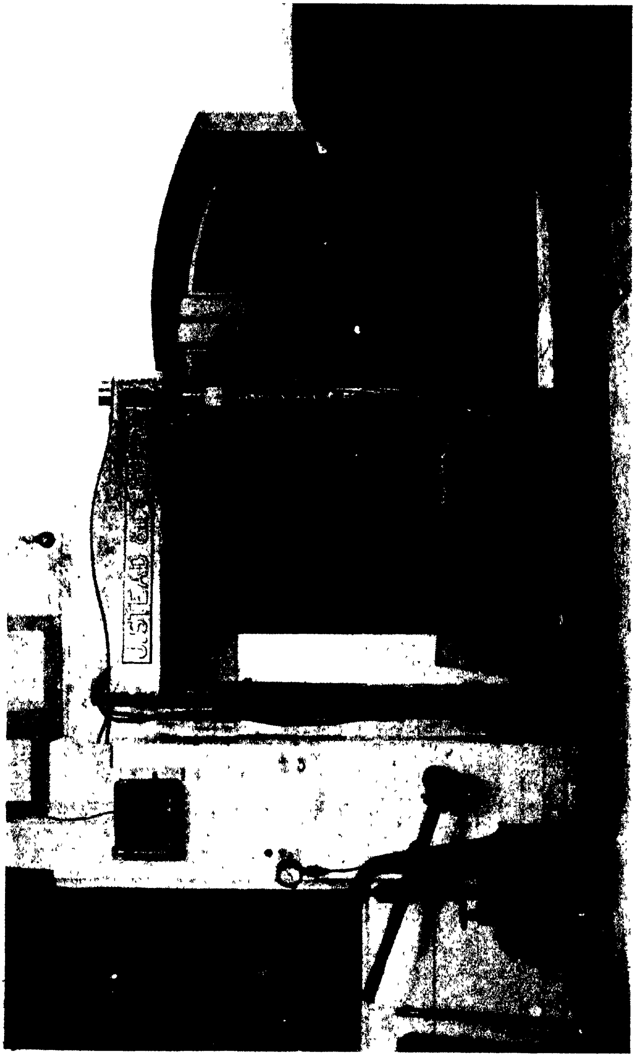
FIG. 145.—Vertical Press.

In preparing each piece for the press, it is folded down the centre. Two kinds of card-boards are used, and also metal fencings. The thinner press papers are inserted between each layer of fabric. When the work of cuttling and papering has been done, a piece is placed in the press, three hot metal plates being first laid on the table D, and on the top of these a metal fencing, a thin strip of iron; then follows another piece, folded in papers as described, and on this are placed card-boards and metal fencings, and three additional hot plates. This is done for every piece put in the press.

The press having its full complement of pieces, the hydraulic pump (A, Fig. 146) is started, and the requisite pressure applied. The pieces remain for the first pressing about two hours, then they are refolded and repapered to take out the cuttle marks across the piece. In the second operation, the pieces remain in the press, usually overnight or until cool. Steaming follows, as a rule, to remove any unnatural gloss and stiffness of handle.

Another system consists in using specially prepared boards having metal pieces at the front edge, by which heat, developed by electricity, can be distributed over the surface. Cuttling and preparing is done in the same way, only the heat distributors or boards are applied after every twelve layers of cloth, or may be, more frequently, if greater heat is required in pressing. It will be seen from the illustration (Fig. 146, section of Finishing Room, Leeds University) that on this principle a switch-board is placed on either side of the press, and, at convenient intervals, an electric current is supplied to the heat generators or boards. In this way a more uniform heat is developed throughout the successive layers of cloth in the press.

By the hot plate arrangement, the ends of the pieces, and layers nearest to them, necessarily receive and retain more heat than the layers approaching the centre folds or cuttles, whereas, by the electric system, the heat is more evenly distributed, with less danger of scorching the ends of the pieces, which sometimes happens in the pressing of light fabrics with the hot press: the charging of the press is also more economically done.



B

FIG. 146.

A = Hydraulic pump. B = Press. C = Press table.

(110) *Rotary Press.*

This is a continuous Pressing Machine, Figs. 147 and 148. It consists of the main cylinder C, round which the cloth passes, upper and lower dishes or beds A and B, with removable shell of nickel silver, requisite guide rollers, brush or beater E, and cooling arrangement F. Three powerful rams R are employed, connected with a hydraulic pump. These lift the lower bed B and also the cylinder. Pressure on the cloth is applied by lifting the lower dish B against the cylinder, and the cylinder against the upper dish A, these parts being steam heated at a pressure of 50 to 75 lb.

The cloth, as seen from Figs. 147 and 148, passes over the guide G^1, under G^2, being brushed by E as it passes to the crimping-board or roller D, under the cylinder C, over the upper part of the cylinder to the front top guide roller G^3, then over the cooler F to the folding motion, five to seven yards of cloth being pressed per minute. The fan F^1, which has a high velocity, forces a current of air through the piece immediately after pressing, cooling and conditioning the cloth. The steam gauge attached to the machine indicates the lb. per square inch. The usual pressure on fine worsted goods is 300 lb., and that for low tweeds and union fabrics 700 lb. per square inch. It is claimed that the lustre obtained in this way is permanent. In another form of this machine only a lower dish is used, and the piece pressed once and not twice for each passage under the cylinder.

As regards productive power and economy of working, this machine is superior to the vertical press. There is no folding of the pieces, and they are pressed full width. Perhaps the lustre obtained is not quite so natural as that produced by pressing between press papers. Being so rapidly done, and whilst the piece is in motion, the press is more in the nature of a glaze than a soft lustre, and the handle of the cloth is not of the same character. The chief advantage is that of high productive power, and for this reason, and also on account of the comparative firmness and solidity of texture, it is suitable for the low-class woollen and the union trade. The older and slower system is generally preferred in the finishing of high-class woollens and

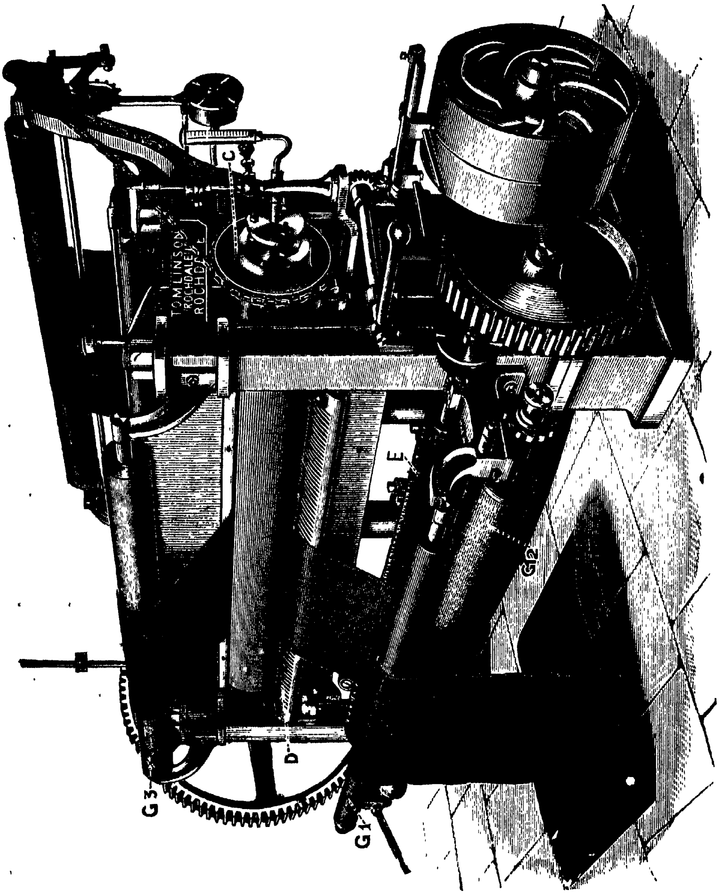


Fig. 147.—Tomlinson's Rotary Press.

worsteds. Still, the rotary machine is used in the worsted trade in pressing prior to dyeing, the vertical press being used for final pressing.

(111) *Intermittent Pressing Machine.*

This is constructed in two forms, the smaller type of machine being illustrated in Fig. 149, and the larger type by the sectional drawings (Figs. 150 and 151). The pieces being pressed on a flat surface, and not on a cylinder as in the rotary machine, have necessarily an intermittent forward movement, and are pressed four times per minute. The pressure applied is from 350 to 500 tons at each stroke. In the sectional drawings (Figs. 150 and 151) two pieces are shown, one above, and the other below the central and steam-heated plate, which is brought into contact

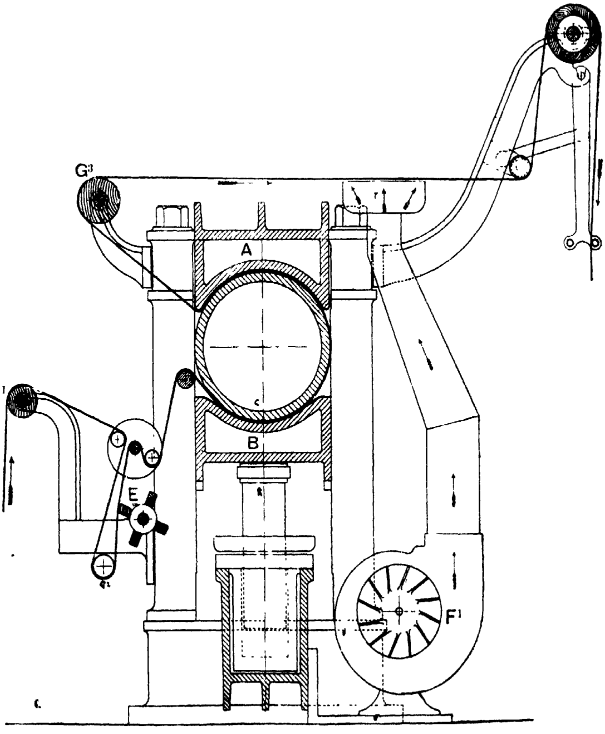
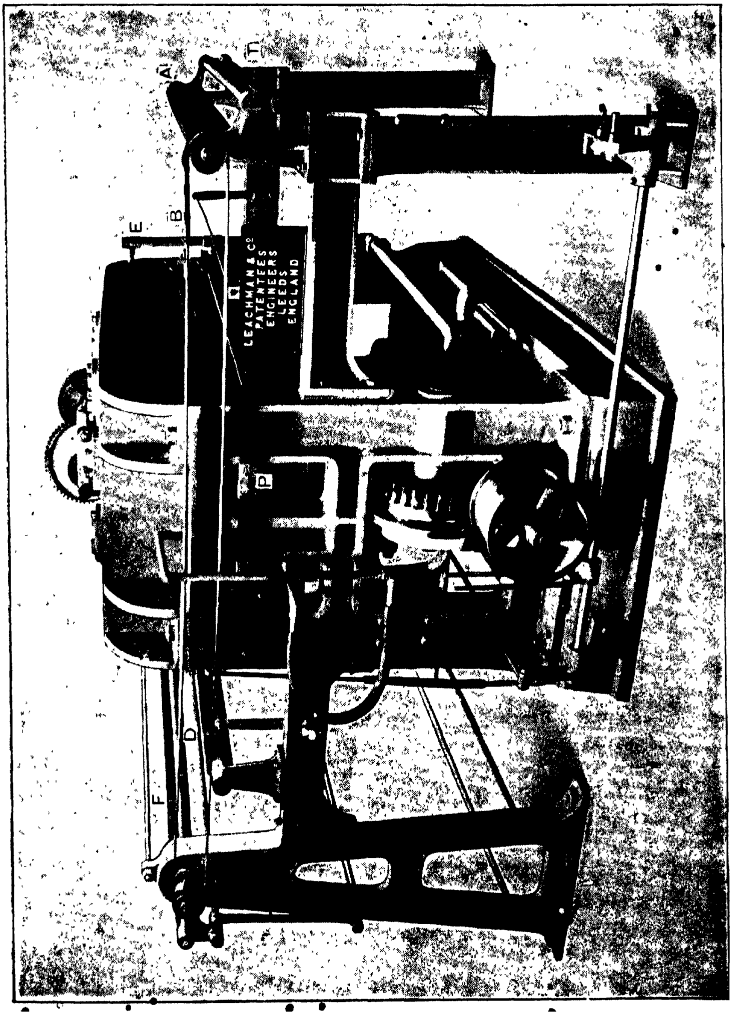


FIG. 148.


A
T
B
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with the lower and upper portion of the machine by hydraulic pressure, imparting an equal degree of lustring and smoothing effect to each layer of fabric.

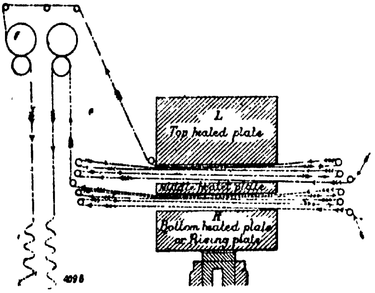

Fig. 150.

The sectional drawings indicate the means for controlling the parts of the press, intermittently and automatically, by the compound cam C; and also the mechanism for producing the conveyance of the pieces from the feed to the delivery rollers.

The cycle of movements comprise, (1) the lifting of the pressure bed K by a small ram inside the large one; (2) the action of the large ram applying the maximum pressure upon the pieces; (3) the removal of the pressure; and (4) the drawing of the pieces forward after each stroke of the bed. All these successive movements are initiated by cam C, opening and closing, as required, a number of valves.

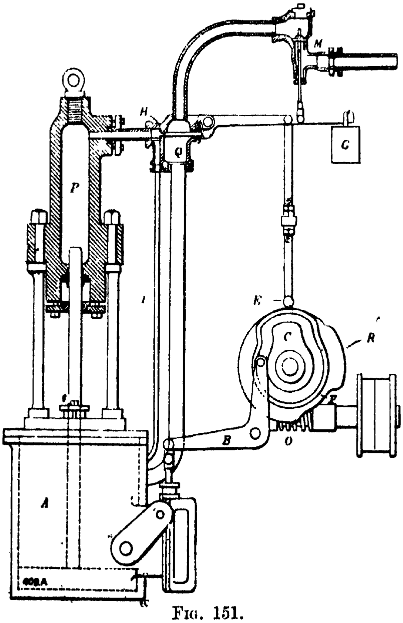

Fig. 151.

In Fig. 151, A is the steam cylinder to which steam is admitted by a slide valve operated by the bell crank lever B. The two steam pipes Q and I are in connection with the two rams, the smaller of which brings the large ram and the plates up to their work. Communication is opened by valve M, between an elevated tank and the large hydraulic cylinder. The hydraulic pump operates when lever connections come in contact with Q, opening valve H. After the full pressure has, for a brief period, been exerted on the cloth, it is, of course, necessary, in order that the piece may travel forward, that the bed K should be lowered. This is accomplished by the projection lifting the runner E, and by the upright connector raising the valve M, forming an exhaust passage.

The conveyance of the cloth through the machine is shown in Fig. 149. On the lower plate or bed is fixed a stop, which sets the drawing rollers in motion, with the releasing of the pressing of the cloth. The pieces pass between a pair of tension rollers T, over front guide roller intermittently driven, between the lower draft or space B, under the roller D, over the roller, returning through the same draft, round roller A, into the upper draft E to the back roller F, and folding motion.

The intermittent movement of the cloth is controlled by the action of the press bed P. During its pressure on the cloth, by a friction drive arrangement, not shown, the movement of the draw rollers is arrested. The plates between the two drafts B and E are steam heated, and the pressure by means of bed P is also under steam control.

CHAPTER XII.

METHODS OF FINISHING.

(112) Routines of Finishing. (113) Woollen Routines of Finishing. (114) Worsted Routines of Finishing. (115) Routines of Finishing for Union Fabrics.

(112) *Routines of Finishing.*

THESE vary with the type of woven manufacture. In the woollen trade, where the whole routine of work is carried out, as a rule, in the same mill, the finish may be diversified, or arranged, to suit the quality of the raw material, and the structure of the yarns and fabric. Or, to put it in a different way, thematerial may be selected, the yarn carded and spun, the texture set in the reed, and in regard to picks per inch and other technicalities, for a specific routine of finish. This is also done in worsted manufacturing, but the facilities for carrying out the same are in favour of the woollen manufacturer. The worsted trade is distinctly departmental, or sectional, comprising the top maker, the yarn spinner, the manufacturer, and the finisher. The system has, no doubt, economic features. But the textile manufacturer, producing from the wool to the finished cloth, can devise methods and routine which will impart a character to the finished product distinct from the design and colouring which may obtain in similar classes of fabrics made by a competitor.

(113) *Woollen Routines of Finishing.*

The following are examples of methods of finishing Saxony and Cheviot fabrics:—

SAXONY FABRICS.

No. 1. ORDINARY SAXONY SUITING.

Milled, soft finish, with a slightly fibrous face.

Wool: Sydney.
Warp: 20 skns. left hand twine, 15·3 turns per inch.
Weft: Same as warp.
Set 70 inches wide in the loom, 9's reed 4's, 40 picks per inch.
Finished: 56 inches wide, 15½ to 16 oz. per yard.
Weave: $_2{-}^2$ twill, 36 ends to the right, and 36 to the left.

Routine of Finish.—Knot and mend, scour with alkali and soap, mill to 56-57 inches, wash-off, tenter, cut level, brush and steam, blow with steam on the winding-on frame, brush and steam, hot press, steam.

No. 2. COSTUME CLOTH.

Handle of fabric, soft: surface, lustrous.

Wool: Fine Merino.
Warp: 30 skns. left hand twine, 17·6 turns per inch.
Weft: Same as warp.
Set 74-75 inches wide in the loom, 11's reed 4's, 44 picks per inch.
Finished: 56 inches wide, 12¼ oz. per yard.
Weave: Angled $_2{-}^2$ twill.

In fabrics of this kind, the turns per inch in the yarn are important, especially as they affect the milling and raising.

Routine of Finish.—Knot and mend, scour, mill to 58 inches, wash-off, tenter, raise damp, dry beat, cut, hot press, blow with steam, brush and steam, hot press, steam.

No. 3. CHECKED-BACK JACKETING OR CLOAKING.

Raised on the face, cut clear on the back.

Wool: Cape Merino.
Warp: 30 skns. face yarn, 16·3 turns per inch.
2/30 skns. backing yarn, 12·9 turns per inch.
Weft: As warp.

Set 75-76 inches wide in the loom, 12's reed 6's, 72 picks per inch.
Finished: 56 inches wide, 23½ to 24 oz. per yard.
Weave: double $\frac{2}{2}$ twill, weft stitched, arranged 1 face, 1 back, 1 face.

Routine of Finish.—Knot and mend, scour, mill to 56 inches, wash-off, tenter, raise wet several times from each end, hydro-extract, brush and steam, tenter, hot press, steam, cold press.

No. 4. BEAVER FINISH.

Wool: Sydney.
Warp: 26 skns. left hand twine.
Weft: 14 skns. right hand twine.
Set 82 inches wide in the loom, 12½'s reed 4's, 56 picks per inch.
Finished: 56 inches wide, 34½ oz. per yard.
Weave: 5-end sateen, weft backed, arranged 1 face, 1 back.

Routine of Finish.—Knot and mend, scour with alkali and soap, mill to 57 inches, wash-off, raise from both ends of the piece damp, allow to cool and dry, dry beat, cut, press, boil 3 to 4 hours, cool, rewind from the opposite end, boil from 3 to 4 hours, cool, dye, raise wet on the gig to straighten the fibres, tenter, dry beat, brush, cut, hot press, steam.

No. 5. DOESKIN FINISH.

Wool: Port Philip.
Warp: 26 skns. left hand twine.
Weft: 14 skns. right hand twine.
Set 41 inches wide in the loom, 12½'s reed 4's, 35 picks per inch.
Finished: 27 inches.
Weave: 5-shaft warp sateen.

Routine of Finish.—Similar routine to the beaver with certain detail modifications to suit the quality and the weight of the cloth. For example, the boiling process might be repeated three or four times, and the raising and cutting also varied.

No. 6. WOOLLEN VESTING: SOFT FINISH.

Wool: Merino.
Warp: 20 skns. for the face and back; 13·6 turns per inch.
Weft: 20 skns. for the face and back, 11·9 turns per inch.
Set 38 to 40 inches wide in the loom, 14's reed 4's, 56 picks per inch.
Finished: 28 inches wide, 12½ to 13 oz. per yard.
Weave: double cassimere.

Routine of Finish.—Knot and mend, scour, mill to 29 inches, wash-off, tenter, raise damp several times from each end, hydro-extract, brush and steam, tenter, cut level, hot press, blow, hot press, steam, cold press.

No. 7. LOW WOOLLEN SERGE: MADE OF EXTRACTED CARD WASTE.

Warp: 10 skns., left hand twine, 13·25 turns per inch.
Weft: 10 skns., left hand twine, 10·9 turns per inch.
Set 76 inches wide in the loom, 12's reed 2's, 24 picks per inch.
Finished: 56 inches wide, 20 oz. per yard.
Weave: $\frac{2}{2}$ twill.

Routine of Finish.—Knot and mend, raise before scouring, scour, mill to 57 inches, wash-off, tenter, blow, dye, tenter, cut, blow, brush and steam, hot press, steam.

No. 8. WOOLLEN RUG FINISH.

Wool: River Plate.
Warp: 15 skns. face and back, 2/40's cotton centre.
Weft: 15 skns. face and back.
Set 68 inches wide in the loom, 13's reed 5's, 52 picks per inch.

Finished: 2 yds. 5 inches; 54 inches wide, weighing 3 lb. 15 oz.

Weave: ${}_{2}{-}^{2}$ twill, double, centre warp stitched, arranged 1 face, 1 back, 1 centre, 1 face, 1 back.

Routine of Finish.—Knot, mend, fringe, scour, mill, tenter, raise, cut, brush, steam, cold press.

CHEVIOT FABRICS.

No. 9. COSTUME CLOTH.

Wool: Cheviot.

Warp: 15 skns. left hand twine, 8·5 turns per inch.

Weft: Same as warp.

Set 68 inches wide in loom, 13's reed 2's, 26 picks per inch.

Finished: 56 inches wide, 12 oz. per yard.

Weave: ${}_{2}{-}^{2}$ twill.

Routine of Finish.—Knot and mend, scour with alkali and soap, mill to 57 inches, wash-off, tenter, brush and steam, hot press, steam.

No. 10. FINE SUITING.

Wool: Super Lamb Pick.

Warp: 15 skns. and 2/25 skns.

Weft: 15 skns.

Set 66 to 67 inches wide in the loom, 13's reed 3's, 34 picks per inch.

Finished: 56 inches wide, 16 oz. per yard.

Weave: Angled ${}_{2}{-}^{2}$ twill.

Routine of Finish.—Knot and mend, scour, mill to 56 inches, wash-off, tenter, brush and steam, cut, brush and steam, hot press, steam.

No. 11. FRIEZE.

Wool: Highland (Black-face sheep).

Warp: 7 skns.

Weft: Same as warp.

Set 62 inches wide in loom, 8's reed 3's, 28 picks per inch.

Finished: 56-57 inches wide, 38-40 oz. per yard.

Weave: $\frac{2}{2}$ twill, cut 2's.

Routine of Finish.—Scour, mill, press, steam.

No. 12. LINED OVERCOATING.

Wool: Cheviot.

Warp: 15 skns. left hand twine, 11·1 turns per inch.

Weft: Same as warp.

Set 73 inches wide in the loom, 8's reed 6's, 48 picks per inch.

Finished: 56 inches wide, 24½ to 25 oz. per yard.

Weave: Double cassimere twill, sateen warp stitched.

Routine of Finish.—Knot and mend, scour, raise damp, mill, wash-off, tenter and blow with steam.

(114) WORSTED ROUTINES OF FINISHING.

Examples are given below in the styles of finish applied to Botanys,—fancy and piece-dye—vestings, covert coatings, crossbred worsteds, and shawls.

No. 1. WORSTED COATING.

Clear finish, or typical worsted piece-dye finish.

Warp: 1 thread of 2/50's left hand twine, 19·2 turns per inch.

1 thread of 2/50's right hand twine, 16·9 turns per inch.

Weft: Same as warp.

Set 69 inches wide in the loom, 18's reed 8's, 120 picks per inch.

Finished: 56 inches wide, 24·1 oz. per yard.

Weave: Double $\frac{2}{2}$ twill.

Routine of Finish.—Knot and mend, blow with steam to set the piece, scour with soap only, tenter, brush and steam, cut clear, blow, dye, tenter, brush and steam, cut clear, blow, brush and steam, hot press, steam, cold press.

No. 2. WORSTED SUITING: CLEAR FINISH.

Warp: 2/40's face and back, 16·1 turns per inch.
Weft: Same as warp, 12·1 turns per inch.
Set 66 inches wide in the loom, 14's reed 8's, 112 picks per inch.
Finished: 56 inches wide, 21 oz. per yard.
Weave: Double twill.

Routine of Finish.—Knot and mend, scour, tenter, brush and steam, cut, brush and steam, blow, brush and steam, hot press, steam, cold press.

No. 3. WORSTED SUITING: SINGLE FABRIC.

Warp: 2/30's left hand twine, 9·5 turns per inch.
Weft: Same as warp.
Set 66 inches wide in the loom, 14's reed 4's, 56 picks per inch.
Finished: 56 inches wide, 14 oz. per yard.
Weave: $_2{-}^2$ twill.

Routine of Finish.—Knot and mend, scour with alkali and soap, tenter, brush and steam, cut clear, brush and steam, hot press, steam, cold press.

No. 4. LINED OVERCOATING: FINISHED ON BOTH SIDES.

Warp and weft: 2/40's face and back.
Set 69-70 inches wide in the loom, 15's reed 6's, 90 picks per inch.
Finished: 56 inches wide, 17 oz. per yard.
Weave: $_2{-}^2$ twill face, plain back, warp stitched, arranged 1 face, 1 back, 1 face.

Routine of Finish.—Knot and mend, scour, tenter, brush and steam, cut, four times on the face and once on the back, brush, blow, cool, steam, afterwards roll up and allow to cool, hot press, steam, cold press.

No. 5. VESTING.

Warp and weft: 2/50's.

Set 32 inches wide in the loom, 13's reed 8's, 108 picks per inch.

Finished: 28 inches wide, 10 oz. per yard.

Double weave, centre warp for spotting.

Routine of Finish.—Knot and mend, scour, tenter, brush and steam, cut, brush and steam, blow, brush and steam, hot press, steam, cold press.

No. 6. COVERT COATING: CLEAR FINISH.

Warp: 2/40's worsted.

Weft: 30 skns. woollen.

Set 68 inches wide in the loom, 18's reed 4's, 56 picks per inch.

Finished: 56 inches wide, $14\frac{3}{4}$ oz. per yard.

Weave: ${}_{2}$—^{2} twill and 4-shaft mat.

Routine of Finish.—Knot and mend, scour, mill to 56 inches, brush, cut, brush and steam, blow, steam, roll up and allow to cool, hot press, steam, cold press.

Another method of finishing this style of cloth is to leave the fibre on the face, and this would require that the cloth should be more heavily milled than the one for which the particulars are given.

No. 7. CROSSBRED WORSTED.

Warp: 2/30's left hand twine, 9·7 turns per inch.

Weft: Same as warp.

Set 68 inches wide in the loom, 12's reed 4's, 46 picks per inch.

Finished: 56 inches wide, 14-15 oz. per yard.

Weave: Angled ${}_{2}$—^{2} twill.

Routine of Finish.—Knot and mend, scour, mill to 57 inches, wash-off, tenter, cut level, brush and steam, blow, hot press, steam, cold press.

No. 8. SHAWL.

Warp and weft: 2/30's worsted.

Set 66 inches wide in the loom, 12's reed 4's, 48 picks per inch.

Finished: 4 yards 22 inches long, 55 inches wide, weighing 3 lb. 6 oz.

Weave: $_{2}{-}^{2}$ twill.

Routine of Finish.—Knot, mend, fringe, scour, tenter, cut, press.

(115) ROUTINES OF FINISHING FOR UNION FABRICS.

No. 1. COTTON WARP AND WOOLLEN WEFT SUITING.

Warp: 2/30's cotton.

Weft: 20 skns. woollen, 12·2 turns per inch.

Set 74 inches wide in the loom, 11's reed 4's, 48 picks per inch.

Finished: 56 inches wide, 12·8 oz. per yard.

Weave: Angled $_{2}{-}^{2}$ twill.

Routine of Finish.—Knot and mend, scour, mill, wash-off, tenter, brush and steam, hot press, steam, cold press.

No. 2. UNION RUG.

Warp: 2/20's cotton.

Weft: 2/30 skns. Saxony. 17·7 turns per inch.

Set 114 inches wide in the loom, 12's reed 2's, 75 picks per inch.

Finished: 72 inches wide, 31 oz. per yard.

Weave: Backed $_{3}{-}^{1}$ twill.

Routine of Finish.—Knot and mend, scour, mill, wash-off, raise four times from opposite ends, tenter, brush and steam.

No. 3. COTTON WARP BEAVER: FACE FINISH.

Warp: 2/30's cotton.

Weft: 25 skns. mungo, 12·65 turns per inch.

Set 90 inches wide in the loom, 13's reed 4's, 72 picks per inch.
Finished: 56 inches wide, 22 oz. per yard.
Weave: 5-shaft sateen weft reversible.

Routine of Finish.—Knot and mend, scour, mill, raise several times, tenter, dry beat, cut, hot press, dye, boil, wash-off, tenter, dry beat, cut, brush and steam, hot press, steam, cold press.

It is, of course, understood that these routines of finish are, in practice, varied according to the structure of the fabric, and the exact degree or nature of finish required.

THE END.

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